STUDIES ON THE PATHOGENICITY AND MANAGEMENT OF ROOT KNOT *MELOIDOGYNE INCOGNITA* INFESTING OKRA (*ABELMOSCHUS ESCULENTUS*) FAMILY MALVACEAE UNDER LABORATORY CONDITIONS

THESIS SUBMITTED BY

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DEDICATED
TO
MY FATHER
LATE SHRI DASHARATHA MISHRA

Content

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Certified that **Kaushal Kumar Mishra** has worked under my supervision for his D. Phil thesis entitled "**Studies on the Pathogenicity and Management of Root Knot *Meloidogyne incognita* infesting Okra (*Abelmoschus esculentus*) Family Malvaceae under Laboratory conditions**".

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INTRODUCTION

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Increasing food demand and awareness of the impact of agricultural management practices on the environment are posing a strong challenge to agriculturalists. Among constraints of agriculture production, pathogens play an important role. Unfortunately, very often the same and similar crops are continuously cultivated in the same field thus leading to the increase of populations of specific pests and diseases that are necessary to control. In India, the root-knot nematodes ***Meloidogyne incognita, M. javanica*** and ***M. arenaria*** are the major and often the only pest problem of vegetable crops. So far, methyl bromide has been instrumental in solving problems of intensive crops. Lately, methyl bromide has become the cause of strong concern because of its high ozone depletion potential and it has been decided that in the developed countries this fumigant will be phased out in the year 2005. Therefore, plant protectionists are urged to find methods and/or means of control that can substitute methyl bromide and still ensure an acceptable level of plant protection. Among the possible alternatives

to methyl bromide for soil disinfestation are nematicides, soil solarization, steaming, resistant root-stocks and resistant cultivars, or a combination of them which are briefly discussed here.

Because of the impressive yield increase following their application, nematicides are the most popular means for controlling nematodes. They are much less expensive than methyl bromide and the farmer can apply them by himself. However, only some of them are as effective as methyl bromide, while most can provide an acceptable level of plant protection only in the presence of a low to medium nematode infestation. Moreover, for many of them the control of other soil borne plant pathogens and weeds is uneffective or very limited and, therefore, they can only partially substitute methyl bromide.

Vegetable crop are rated as one of the most important agricultural and commercial crops in our country. These serve as the major sources of carbohydrates, proteins, vitamins and minerals. The best way to increase the productivity under Indian conditions is to remove the constraints in which diseases and pests are

given the top most priority. The plant-parasitic nematodes like root-knot nematodes (***Meloidogyne*** spp.) reniform nematodes (***Rotylenchulus reniformis***), lesion nematodes (spp.) etc. have also been reported to cause serious damage to vegetable crops in India.

Among the several vegetable crops grown in our country, ***Abelmoschus esculentus*** (Okra) of family Malvaceae is one of these. It is one of the most important vegetable crops in India, which are grown round the year. Its fruits contain carbohydrates, proteins, minerals and vitamins. The Okra crop is cultivated in U.P., M.P. and Bihar.

Nematodes are triploblastic, bilaterally symmetrical, unsegmented psudocoelomic, invertebrates. In the early year of 20^{th} century, N. A. Cobb introduced the term Nematology for the study of Nematodes. Nematodes that attack plants are microscopic roundworms found in the soil, which feed on or in plant roots. The characteristics of all the plant-parasitic nematodes include a feeding apparatus known as stylet. As a result of damage to the plant's root system, most symptoms of nematode attack are related to an insufficient supply of

water and nutrients to above-ground plant parts. Plants can experience yellowing, stunted growth, wilting and failure to respond adequately to irrigation and fertilization. Nematode damage may also render the plant more vulnerable to attack by soilborne fungal and bacterial pathogens. Plants with symptoms of nematode damage are not distributed uniformly throughout the field, but rather affected plants occur in patchy areas. The root galls are found on the root system, the symptoms on the areal parts are generally caused due to malnutrition and deficiency of water. Normally the nematodes by themselves do not kill the plants, instead death of plant is actually the result of secondary infections by fungi and bacteria. The size of knots on the root depend upon the type of infection, host plant and species of causative nematodes. ***M. incognita*** and ***M. javanica*** produced larger galls, while ***M. hapla*** produced smaller galls. These galls are of firm consistency and are deep seated.

Root-knot Nematodes (*Meloidogyne spp.)*

The root-knot nematode (***Meloidogyne spp.)*** was discovered and reported in 1855 by M. J. Barkeley. He noticed galls (knots) on roots of cucumber. In 1887, E. A. Goeldi reported ***M. exigua*** from root-knot of coffee in Brazil. Root-knot nematodes, a common name given to the species of ***Meloidogyne (Mel-oid-o-gyne)*** is derived from greek melon (gourd) +Oeides, Oid (resembling) + gyne (female) = gourd-like females. In 1855, Barkeley, first reported it but incorrectly called as ***Vibrio***. In 1887, Goeldi described the same as ***M. exigua.*** In 1949, Chitwood, published his historic revision of the root-knot nematodes and separated the genus ***Meloidogyne*** from the genus, ***Heterodera*** on the basis of very specific morphological differences. He justified the name ***Meloidogyne*** given by Goeldi for root-knot nematodes. Chitwood (1949) recognised and described five sepecies namely ***M. arenari, M. exigua, M. hapla, M. incognita*** and ***M. javanica.*** Whitehead (1968), later recognized 23 morphological different species. A total of 54 species of ***Meloidogyne*** were reported by 1985. In India, Barber (1901) at first described root-knot nematodes on tea plantations as ***Hetrodera ridiciola*** from Kerala. So far

the following 12 species have been reported in India, ***M. Africana, M. arenaria, M. brevicauda, M.exigua, M. graminicola, M. graminis, M. hapla, M. incognita, M. indica, M. javanica, M. lucknowica*** and ***M. thamesi.***

The mature females of ***Meloidogyne spp.*** are swollen pear-shaped with elongated anterior end. The body covering is soft and white and does not form a cyst. Cuticle is lightly annulated. Tail is absent. Anus and vulva are terminal. Female stylet is slender with well developed basal knobs. Eggs are laid in a gelatinous matrix, None is retained in the body. Males are vermiform and migratory. Its second stage juvenile larvae are migratory and act as infective stages to their hosts.

In the identification of species perinneal pattern of the female is greatly helpful. The perinneal patterns are configurations, especially of ***Meloidogyne*** species, on the cuticular surface of regions around anus. The perinneal patterns of the four major species are explained below:-

M. javanica. The distinctive feature is the presence of lateral field and two lateral incisures which cut through the striae so that few or no striae

extend unbroken from the dorsal to the ventral sector of the pattern. These lines may extend completely across the pattern just above the anus, although a distinct whorl is present at the body terminus.

M. incognita. Perinneal pattern is somewhat oval. Lateral field absent or if present, there is no evidence of lateral lines, but along these areas both the dorsal and ventral striae may extend from the inner striae towards vulva.

M. arenaria. Arch is low and rounded except when the ventral striae are extended to form wings. Numerous short, disordered striae occur near lateral lines where dorsal and ventral striae meet.

M. hapla. Lateral lines may be marked by only slight irregularities in the striae or the striae of the dorsal and ventral sectors may meet at a slight angle along the line. Arch is low,

somewhat rounded. Distinct punctations usually are present at the body terminous just above the anus, a specific character not found in any other species.

Development and Life Cycle

Meloidogyne spp. are endoparasites of underground parts of the plants. The eggs and the second stage juveniles may be present in the soil, but the active phase is always associated with the host.

Pre-Parasitic Stage

The life cycle starts from the eggs, usually in one-celled stage, deposited by female. Eggs are deposited in a gelatinous matrix which normally protrudes out of the host tissues. The gelatinous matrix holds the eggs together in egg masses. Generally one egg mass contains 400 to 500 oval eggs, although the number may go up to 1000 to 2500.

The development of embryo starts within hours of deposition, resulting in two, four, eight cells and so on until fully formed larvae with a visible stylet lie coiled in the egg membrane. The embryo and first stage larvae are

highly resistant to drier conditions. After 1st moulting, second stage larvae are formed within egg. Hatching occurs under suitable environmental conditions. Hatching may be delayed under adverse environmental conditions to ensure the survival of developing organism. The larvae emerge out by a hole made at the end of egg shell by stylet.

Newly hatched second stage juneniles are smaller, slender and about 0.3 to 0.45 mm in length. They move freely in soil in search of a suitable host. They have plenty of glycogen and glycolipids as reserve food. The ***Meloidogyne spp.*** larvae can be detected up to the depth of 1.8 to 2.4 cm in sandy soils.

Parasitic Stage

Penetration and Development In the Host

When second stage juvenile comes in contact with the host, it tries to enter the roots at the meristematic region. Out of a large number of larvae attached on the root surface, only some are able to penetrate. The penetration occurs at the weak (thinner) spot on the epidermis with the help of stylet.

After entry, the larvae move mostly between undifferentiated root cells and reach the endodermis where they prefer to rest with the head in the developing stele near the region of cell elongation, and the body in the cortex. During feeding the larvae pierce the cell wall with their stylet, and inject secretion from oesophageal glands. They cause hypertrophy, enlargement of cells and hyperplasia (increased cell division) leading to the formation of smaller or larger galls. In the meantime, J_2 stage larvae are transformed into J_3 by second moulting and thereafter into J_4 by third moulting, and finally they become full adult after fourth moult.

Root-knot nematodes of the genus ***Meloidogyne*** constitute one of the major groups of plant parasites known for their destructive effects on plant growth and yield. According to Sasser (1977), ***Meloidogyne*** spp. were more widely distributed throughout the world than any other major group of plant-parasitic nematodes. Their role as initiators, aggravators, resistance breakers and being the causative agents of plant diseases is well recognized by now. ***M. incognita*** is an important nematode pest. The survey revealed that

their several species cause great loss of various extent to the vegetable crops in India. The present study is conducted encompassing ***M. incognita*** infestations around ***A. esculentus*** (Okra).

Since under Indian conditions the behaviour of ***M. incognita*** on Okra is not known, therefore, during the present investigation, the main objective was to generate complete information on the host parasite relationship between Okra plant and ***M. incognita***.

A certain degree of geographic adaptations is evident amongst the species of ***M. incognita***. ***M. hapla*** are rarly found in tropical areas. The most widely prevalent species in tropical region are ***M. incognita, M. javanica and M. arenaria.*** They infest a large number of crops specially vegetables like tomato, Okra, Carrot, cucurbits, beans etc. In addition to direct damage to the root system which affect the plant nutrition, these nematodes are indirectly associated with many fungal and bacterial diseases causing secondary infection. When the root-knot nematodes infect the host at an early stage, such as during the seedling stage, the losses are very high and the infected plants may die due to poor nutrition

and secondary invasion by other pathogens. The root-knot attack on Okra can cause severe stunting, yellowing, early defoliation, widespread development of root galls, and reductions in yield. Decreased root branching and root growth often produced wilting. In addition, root rots can occur as a result of secondary fungal infections. When soil populations of root-knot nematodes are high at planting, seedlings may be stunted or killed, resulting in patchy stand establishment. Under lighter infestations, symptoms may not be obvious until later in the season. The clearest symptom used in diagnosis of the presence of root-knot nematode is the appearance of galls (swollen areas) on the roots of infected plants. Galls may be present as a few spherical swellings or they may cover large areas as extended swellings. They are easily distinguished from the nitrogen fixing ***Rhizobium*** spp. nodules normally associated with bean and other legume plants.

Root-knot nematode populations can build quickly on the crop, which can potentially cause great losses to any susceptible crops that follow. The damage threshold for root-knot nematodes can be very low to very high. Consequently, pre-plant treatment of the field with

nematicides is recommended for any detection of the nematode in soil samples or in the previous crop. Yield losses of 50 to 90 percent are often reported on snap beans due to root-knot nematode populations. The nematode is commonly found attacking a wide range of fruit and vegetable crops in most growing areas. For the past 30 years, most fruit and vegetable growers have been able to avoid serious losses from root-knot nematode (***Meloidogyne*** spp.) by regularly applying nematicides. Factors such as the species involved, the initial nematode population in the soil, the crop cultivar, and environmental conditions determine how much damage the crop experiences. Damage from root-knot is usually greater during the fall cropping season, when higher soil temperatures permit faster buildup of the population. However, if fields have experienced summer flooding, nematode populations are low at the start of the season.

The estimates of crop loses due to root-knot nematode made by Lamebrti, Greco and Zouchi (1975) in Italy, Malta and Algeria have revealed that severe attack of ***M. incognita*** could cause 50% losses in tomato

fields. They estimated about 30-60% losses in brinjal crop. Sasser (1979) had estimated the losses due to root-knot nematodes in vegetable crops in the tropics. In tomato and brinjal, the yields reduced by 29% and 23% respectively, by ***Meloidogyne.*** In Okra, the infestation of ***M. hapla*** could cause 22% loss in yield.

The significance of ***Meloidogyne*** led to the formation of the International ***Meloidogyne*** project (IMP) in July 1975 with its headquarters at North Carolina State University, Raleigh (USA). The project had three principal goals,

(1) To increase production of economically important food crop in developing countries.

(2) To upgrade crop protection capabilities of the developing countries.

(3) To advance and disseminate knowledge about the world's most important group of plant-parasitic nematodes. The project was completed successfully in September, 1984.

Non fumigants

These nematicides are generally less effective than the best fumigants. They kill only active stages of the nematodes but not eggs, of which they may only delay hatching. Nevertheless, they are not phytotoxic and, therefore, can be used on established crops. However, their application on established crops, already showing severe damage, is useless and may cause residues in the edible parts of the plants. Their use is suggested when nematode soil population densities at planting are from low to medium. They possess insecticide activity as well. In general, these nematicides are formulated as granules containing 5-10% active ingredients and, therefore, their application is rather simple. The suggested rates are 10-20 kilogram active ingredient/hectares (referred heretofore as kg a.i./ha).

Aldicarb (Temik) a carbamate compound with systemic activity is one of these nematicides. Although Aldicarb seems more effective than other non-fumigant nematicides against cyst forming nematodes, its efficacy against a wide range of nematodes and insects is well documented. It might show phytotoxicity to some crops

even at the suggested rates. It is primarily used as an insecticide but is registered for nematodes in Arizona. There is little evidence in the 1080 data of the high recommended application rates for nematodes during the planting window.

Fensuphothion (Terracur P or Dasanit) an organophosphate compound with systemic activity used as nematicide as well as an insecticide. It can be applied before or after sowing or even on standing plant. They are effective at lower dosage. It might show phytotoxicity at higher dosage.

Carbofuran (Furadon or Curatter) This phosphorganic chemical, although used as a soil insecticide, also shows nematicide activity, but it may result phytotoxic to some crops. Its nematicide activity lasts shortly but, usually, accumulation of its residues in plants is not a problem.

Phorate (Thimet) Phorate is an organophosphate insecticide used occasionally by sweet corn producers, primarily to manage wireworms. It can also aid in the management of corn rootworms, white grubs, and mites. Phorate granules are never exposed, because they are

always incorporated into the soil when applied. Applications can take place only at planting and/or during one cultivation over the course of the growing season. The median price of phorate is $9.75 per pound of active ingredient, and the average cost per application in 1996 was $10.34 per acre. Phorate may be applied up to 30 days before harvest (PHI=30 days), and the restricted entry interval (REI) under the Worker Protection Standard is 48 hours. During 3 of the 5 years in which usage data have been collected, sweet corn growers applied Phorate to a range of 20 to 36 percent of the state's total sweet corn acreage in USA, at an average rate per application ranging from 1.1 to 1.6 pounds of active ingredient per acre, an average of 1.0 to 1.6 times. Total phorate usage on sweet corn has ranged from 14,600 to 21,900 pounds of active ingredient annually (9-13).

Acephate (Orthene) is also an organophosphate, used as insecticide as well as nematicide. Its application rates are 0.5 - 1 lb a.i./acre. It is typically applied at 1 lbs. a.i. per acre at late season. **Maximum label dosage** 8 lbs a.i. per season; **actual dosage** 2 lbs a.i. per

season. It can be used as foliar spray, root-dip treatments, seed treatment and soil treatment.

Prophos **(Mocap or Ethoprophos)** is another phosphorganic, which acts as a contact nematicide and, therefore, is effective only against nematodes living free in the soil. It also has insecticide activity and sometime may show phytotoxicity.

The objective of the current study was to develop strategies for controlling nematodes without the use of fumigation, which can be an effective control. But the latter is expensive and has undesirable impacts on non-target organisms in the soil. Because of the broad spectrum effects of fumigation many beneficial soil ecological processes, such as nutrient cycling and biological control, are disrupted. Therefore, the study has focused on the recommendation for integration of crop rotation strategies and cover crops with the use of non-fumigant nematicides.

Consumer concerns will be addressed if the use of the nematicides still available, will be limited to cases

of real necessity and at the lowest rates required to reduce nematode population densities to non-damaging levels and to prevent plant invasion for a period not necessarily as long as the crop cycle, but just long enough to allow normal plant growth and yield. Row and planting site applications of nematicides could be as effective as broadcast application in many cases. Reduction of the amount of nematicides used in agriculture can also be achieved by considering the nematode biology and by integrating chemical with non-chemical means of control. Among these soil treatment by nutrients mixed with nematicide application could be useful in Indian conditions. The application of Neemcake and Urea has been tested in the present investigation from this standpoint.

Among the several methods of applications of nematicides, seed treatment is receiving much attention as it is economical and providing larger protection to their seedling in their initial stage of growth (Joshi and Patel, 1996). Soil treatment provide effective protection for longer duration and reduction in nematodes population (Jain and Bhatti, 1991 and Weingartner and Shumaker,

1990). Besides, combined application of seed treatment along with soil treatment is recent and more effective to increase plant growth and yield, and reduce root gall formation and nemic population in soil (Paruthi and Gupta, 1985). Therefore, different treatment methods were employed to control ***M. incognita*** on Okra in the present investigations.

Objectives

The study encompassed the following:

1. Studies on the effect of ***M. incognita*** on growth and yield of ***Abelmoschus esculaentus*** (Okra).
2. Studies on penetration and life cycle of ***M. incognita*** of ***A. esculentus.***
3. Screening of ***A. esculentus*** varieties for their resistance against ***M. incognita.***
4. Effect of nematicides used as seed treatment for the control of ***M. incognita.***
5. Effect of nematicides used as pre-inoculation soil treatment on ***M. incognita*** one day before sowing of seeds of Okra.

6. Effect of nematicides used as post-inoculation soil treatment on ***M. incognita*** two weeks after germination of plants.
7. Effect of nematicides along with Neem cake and Urea used as soil treatment against ***M. incognita*** infesting ***A. esculentus.***
8. Effect of combined application of seed treatment and soil treatment against ***M. incognita*** infesting ***A. esculentus.***

REVIEW OF LITERATURE

REVIEW OF LITERATURE

In this chapter general review of the literature on the association of plant parasitic root-knot nematodes ***M. incognita*** (Chitwood, 1949) on vegetable crops particularly ***A. esculantus*** (okra) is undertaken. This review cover the literature available on the effect of ***M. incognita***, penetration and life cycle, screening of varieties resistance and control of ***M. incognita*** by seed treatment, soil treatment and combined application of seed treatment with soil treatment.

Chitwood 1949, did much towards the identification and taxonomy of ***Meloidogyne spp***. He reeastablished the genus ***meloidogyne*** of Goeldi 1887) published in 1892. ***Meloidogyne spp***. are distributed world wide and these are some of the most prevalent ones than any other group of plant parasitic nematodes, Sassar (1977). Sen and Dasgupta (1983), reported that root-knot nematodes (***Meloidogyne spp.***) are the most serious ubiquitous and polyphagus plant parasitic nematodes. A review on the occurrence and distribution of the numbers of this genus in India has been presented. This shows the occurrence of 10 species on 352 plant hosts by these

authors in India. Yet the picture on distribution is far from complete for which a compilation of records from various states by the workers in this field from various part of the country is needed. Without adequate geonematological data diagnostic services by field level workers and specialists can not be taken up with ease and precision.

Furthermore, ***Meloidogyne spp.*** is at the top level among different phytonematodes, that cause great economic losses to yield of different crops. According to Jain and Gupta (1990) root-knot nematodes have been one of the major nematode problems of vegetable crops. Losses in yields to varying degree in tomato and Okra due to ***Meloidogyne spp.*** have been reported (Sen, 1958; Bhatti and Jain, 1977; Jain, Paruthi, Gupta and Dhankar 1986). Losses in tomato yield due ***M. incognita*** to the extent of 46% in Haryana (Bhatti & Jain, 1977) and 39.7% in Karnataka (Reddy, 1985) have been reported. Dahiya & Bhatti (1980) recorded incidence of ***M. incognita*** and ***M. javanica*** on *Lagenaria siceraria.* Paruthi and Gupta (1985) reported that the increased inoculum level of the nematodes, caused reduction in the plant growth, significantly from 100 larvae / kg soil onward in *L.*

siceraria. Lamberti (1975) reported 50% losses in tomato field by severe attack of M. incognita in Italy. Malta. Algeria and 30–60% losses in brinjal crop and 15% in pepper in Italy. Sasser (1979) had estimated the losses due to root-knot nematodes in vegetable crops in tropics. In tomato ***M. incognita*** could reduce yield by 29%, while in brinjal infestation of ***M. javanica*** and ***M. arenaria*** caused 23% loss in yield. In Okra infestation, ***M. hapla*** could cause 22% loss in yield. Estimates to crop losses due to these species and other nematodes on a world wide basis suggested a total loss of about 5% (Taylor and Sasser, 1978).

In India Srivastava (1969) reported 75% loss in brinjal and tomato in Kanpur (U.P.). Seshadri (1970) reported that reduction in yield due to ***Meloidogyne spp.*** ranged from 31.4% to 61.9% in Okra and 26.5% to 73.3% in tomato. Bhatti & Jain (1977) reported 90% loss in okra and 46.2% loss in yield of tomato infested with ***M. incognita*** at an inoculum level of 2000 to 3400 J_2 / kg soil. Singh and Chaudhari (1973) estimated a loss of 18 to 25% in the yield of tomato due to infestation of ***M. incognita*** Keplinger and Abani (1976) reported the

association of ***M. incognita*** on ***Phaseolus mungo***. Singh and Reddy (1981) reported the association of ***M. incognita*** with Frenchbean and suggested that the pod yield of Frenchbean was reduced by 20% with infestation of ***M. incognita***. Amarnatha and Krishnappa (1989) reported predominant association of root-knot Nematodes with sunflower that caused loss of yield to this crop. Rao, Padhi and Acharya (1987) reported association of ***Rohylenchulus reniformis*** as a potential pathogen of Okra cultivar Pusa Sawani at a minimum density of 100 Nematodes / kg soil. Sahoo and Padhi (1985) reported that higher population densities of *R. reniformis* significantly reduce plant growth.

Regarding pathogenicity of ***M. incognita***, Melakebehran, Brooke, Webster and Auria (1985) worked upon the *P. vulgaris* and inoculated one week old *P. vulgaris* with 1000 to 10000 J_2 of ***M. incognita***. Linear regression analysis showed significant ($P < 0.01$) decreased in all plant growth parameters and total yield potential in relation to increase in nematode inoculum Marwoto and Rohana (1987) reported a negative correlation between number of galls and fresh weight of

P. vulgaris and a positive correlation between number of galls and densities of final population of ***Meloidogyne spp***.

Haseeb, Khan and Saxena (1983) described that decrease in Okra plant is directly related with the inoculum level of *R. reniformis*. Haseed and Butool (1989) reported that root-knot nematode *M. incognita*, severely limited growth and oil yield of *Ocimum sanctum* and with the increase in the initial inoculum level, there was a corresponding decrease in root, shoot length, fresh and dry weight and total oil yield. The highest root-knot index was found in plants inoculated with the maximum inoculum level of 15000 freshly hatched J_2 larvae and the lowest at the minimum inoculum level of 50 J_2 larvae.

Alam, Hasan and Saxena (1974) reported that the water absorption capability of tomato seedlings was adversely affected by infection with ***M. incognita*** and it was indirectly proportional to inoculum level. Furthermore, Alam **et al (**1975) reported that the growth in tomato plant (***L. esculentum***) was highly reduced by the infestation of ***M. incognita***.

It has been demonstrated by the studies of Bharadwaj, Sharma, Phunchog (1972) that ***M. incognita*** and ***M. Javanica*** are the serious pests of tomato in the Solan area of H.P. India. Bhatnagar, Mukherjee and Tyagi (1979) found that ***M. incognita*** caused Giant cells and abnormal xylem vessels in ***A. esculantus***. The pathogenicity studies of Dhawan and Sethi (1976) provided evidence of progressive decrease in the growth of egg plant as the inoculum density of ***M. incognita*** increased. Significant reduction in length of shoot and root as also in weight of shoot, was observed at an initial inoculum density of 1000 larvae / kg soil. Gaur and Prasad (1980) describe the relationship between the population density of ***M. incognita*** and damage to egg plant (***Solanum melongena***), and suggested that a population density above 1000 J_2/plant hastened maturity of the crop and shortened the duration of fruiting. Root-knot nematodes were recognized as important plant parasites in Guyana. They were considered an important limiting factor in crop production. The practice of continuous monoculture favoured the rapid build up of nematode populations in the region (Singh, 1972).

The penetration and life history of ***M. incognita*** on different plant host was reported by few workers. Ngundo and Taylor (1975), studied some factors affecting penetration of bean roots by the juveniles of ***M. incognita*** and ***M. javanica*** and reported that 24 hours old J_2 of both species at inoculum level of 100/seedlings failed to penetrate roots of any of the 6 bean cultivars after exposure period of 12, 24 and 48 hours. Freshly hatched J_2 of both the species penetrated at inoculum level of 300/seedlings in 48 hours. Dhawan and Sethi (1976) also made a comparative study on the life history of ***M. incognita*** in healthy and diseased plants and reported that the time of completion of life cycle was similar in both. Siddiqui and Taylor (1970) reported that ***M. naasi*** complete its life cycle in 39-51 days in wheat at 26°C day and during 20°C night temperature.

Attempts for screening of Okra cultivar for their resistance against ***M. incognita*** have also been made by few workers. Alam, Khan and Saxena (1974) analysed interactions of some cultivated varieties of Okra to root-knot nematode ***M. incognita*** and reported that all the varieties of Okra were found to be highly susceptible to

root-knot nematode. Rao and Singh (1977), investigated while working reactions of some varieties and selection of Okra to ***M. incognita.*** These findings concluded that all the 34 varieties of ***A. esculentus*** was favoured the most by ***M. incognita*** and were susceptible to some degree. Thakar, Patel, Patel and Patel (1986) also evaluated seven varieties of okra against ***M. incognita*** and ***M. javanica*** and reported that none of the varieties of Okra were found resistant or moderately resistant.

Several reports are available regarding management of root-knot nematodes by the application of nematicides. Sivakumar, Kuppusamy and Meerzainuddin (1973), evaluated the seed treatment of Okra by the 3%, 6% and 12% doses of carbofuran and found that 6% dosage of carbofuran was effective to reduce the severity of infestation by ***M. incognita*** on Okra, but it does not give absolute protection against root-knot nematodes. Sivakumar Palanisamy and Nagnathan (1976) reported treated with Carbofuran or aldicarb sulphate at rate of 3, 6 or 12 percent a.i. the seeds of okra and sown in soil infested with ***M. incognita*** and ***R. reniformis.*** The roots treated with 12 percent Carbofuran and all doses of

Aldicarb sulphon, examined 15 days after germination were free from root-knot infestation. Mahajan (1978) studies the efficacy of Carbofuran for the control of ***M. incognita*** on Okra and found that penetration of the roots by larvae was the least 4 weeks after the application of 5 g a.i. and 20 g a.i./100 g seed, Furadon (Carbofuran) soluble powder.

Varaprasad and Mathur (1980) found that Aldicarb sulphon 1% a.i. and Carbofuran 2% a.i. were effective in reducing ***M. incognita*** populations on sugarbeet, and improving its plant growth. The studies of Gogoi and Phukan (1990), on efficacy of certain chemicals as seed treatment against ***M. incognita*** on Lentil, concluded that Carbofuran, Phorate Diozionine and Ekalux nematicides were effective at 2% dosage, to reduce number of root-knot galls and egg masses, and increasing the yield of plants. The investigation of Hoda Ameen and Youssef (2001) on integrated control of ***M. incognita*** infecting cowpea, confirmed that highest percentage of nematode reduction was achieved by soaking the seeds in extract of green manures. Pankaj and Siyanand (1992), performed experiments on the efficacy of chemicals as

seed dresses against ***M. incognita*** on Bitterguord and round melon. They reported that carbofuran and phenamiphos provided sufficient initial protection against ***M. incognita*** on both the crops even at lower concentration of 1 percent. The Adicarb, Carbofuran, Fensulphothion and Phorate at their 1 percent and 2 percent doses reduce the penetration of ***M. incognita,*** when applied in eight pulse crops by Mishra (1995).

Sitaramaiah and Vishwakarma (1978), reported that yield of Okra increased at 4 to 8 kg/ha dosage of Aldicarb, during the management of root-knot nematodes as soil treatment but higher dosage i.e. 16 kg/ha and 32 kg/ha of Fensulphothion and Carbofuran were phytotoxic to the plant. Sharma and Midha (1977), reported efficacy of Temik for the control of infestation of ***M. incognita*** on ***A. esculentus***.

The interesting conclusions have been drawn by Reddy and Singh (1979) on the control of root-knot nematodes, ***M. incognita*** infesting tomato by bare root dips in the organophosphate and carbamate groups of Nematicides. They revealed the least root-knot index in the plants inoculated with 500 J2/ part. The roots dipped

in 1000 ppm Oxamyl for 15 minutes. An experiment on groundnut in compassing Carbofuran, Phorate, Cadusafos and Phenamifos @the higher doses (3 Kg/ha) was effective out of all the other concentration **viz**. 1 and 2 Kg/ha, to increase the growth of plant and reduce infestation by ***M. javanica*** Joshi and Patel (1996). The pre-inoculation soil treatment by 4 Kg /ha doses of Mocap and Phorate increased the growth of sunflower plant and reduce the ***M. javanica*** infestation around this plant demonstrated by Amarnatha and Krishnappa (1992). Sebuphose followed by Carbofuran applied at 4 Kg ai/ha, at the time of inoculation were most effective in controlling ***M. javanica*** infesting groundnut (Ishwarbhatt and Krishnappa 1990). On the other hand, Mocap applied @ 2 Kg ai /ha, 14 days after inoculation was found to be the least effective in controlling the Nematodes in this study. According to Cassassa, Matheus, Crozzoh and Casanova (1995) reported that Mocap 4 g a.i./tree showed tendency of diminish nematode population and increased yield of Psidium guajava again ***Meloidogyne spp***. Jain and Gupta (1990) found that 1 kg/ha dosage of aldicarb was effective to increase yield of Okra plant.

Attempt was made by few workers to use oil cakes or leaves of different plants either alone or in combination with Nematicides. The treatment by various modes, other than nematicides to control ***M. incognita*** infestation have been attempted. It was advocated recently by Kumar, Prasad, Ray and Singh (2001) that the application of natural product like leaf extracts of **Thevetia nerifolia** could prove to be more safe in term of bio degradability of chemical in soil, as well as more effective to control root - knot infections. Ram and Gupta (1980) reported that 30 gm / km soil and 40 gm / kg soil neem larvae provide better plant growth in term of shoot and root length, fresh shoot and root weight with reduction in root galling in chickpea (*Cier arietinum*). Siddiqui, Khan and Khan (1976), suggested that oil cake of neem, ground nut, mustard and caster were most effective to increase growth and yield of vegetable crops and reduce root-knot nematode infestation. Singh and Sitaramaiah (1971), reported that urea is the most effective source of nitrogen and the degree of nematode control increases with the increase amount of nitrogen applied after the amendment of soil by sawdust. Yein,

Singh and Chhabra (1977), studies on the effect of pesticides and fertilizers singly and in combination on the root-knot nematode infesting mung and reported that the soil application of Aldicarb (1.5 kg/ha) alone or in combination with nitrogenous (12.5 kg/ha) and phosphate (40.0 kg/ha) fertilizers significantly reduced the nematode population and their galls on the roots. Majumdar and Mishra (1994), found that the neemcake protect the early stage of germination of seeds from nematodes. The Neem seed powder along with Carbofuran 1 Kg/ha provide greater yield and reduce the population density of ***M. incognita*** infesting chickpea. It also increases the benefit cause ratio, as illustrated by Chakrabarti and Mishra 2001. The soil treatment by organic manures, inorganic fertilizers or Carbofuran reduce the nemic density of ***M. incognita*** infesting cowpea (Hoda **et al,** 2001). They also demonstrated that highest percentage of nematode reduction was achieved by seed soaking in the extract of green manures.

The earlier workers also made attempts regarding management of root-knot nematodes by the application of seed treatment along with soil treatment.

Gupta and Verma (1990) suggested that maximum yield of Mungbean were obtained when seed treatment with Carbofuran 1% together with soil treatment by Phorate 1 kg/ha were combined. This treatment protected the plants from root-knot nematode infestation and increased the growth and yield of plant.

MATERIALS AND METHODS

Materials and Methods

The experiments were conducted to study the pathogenicity, life cycle and control of ***M. incognita*** on Okra (***A. esculentus***) cultivar Pusa Sawani. The nematicides for the control were used in single application either as pre-inoculation and post-inoculation soil treatment or seed treatment or in combined application of seed treatment together with soil treatment. The experiments were also conducted for screening of "Resistant" and "Susceptible" varieties of Okra.

Effect of *M. incognita* on growth and yield of Okra cultivar Pusa Sawani

The experiments related with the effect of ***M. incognita*** on growth and yield of Okra cultivar Pusa Sawani were conducted in earthen pots measuring 15 cm in diameter. The pots were filled with 1 Kg steam-sterilized soil. The procedure for sterilization of soil

involved sterilization in an autoclave at 120^0C and 1 Kg/cm^2 pressure for two hours. Then it was passed through a coarse sieve before filling in pots. Two healthy seeds of Okra cultivar Pusa Sawani were sown in each pot. Soon after germination, seedlings were thinned to maintain one seedling in each pot. Seven days old plants were inoculated with different inoculum levels of 0, 10, 100, 1000, 10000 freshly hatched second stage juveniles (J_2) of ***M. incognita*** at logarithmic scale. For inoculation, fresh egg masses were obtained from the culture pots maintained in the laboratory of the Department of Zoology at the University of Allahabad. These egg masses were kept for hatching in glass petridishes. Emerging larvae were collected from the petridishes at 24 hours' interval in a beaker, and population estimated after diluting the suspension to a suitable volume.

The freshly hatched second stage juveniles, almost of the same age group, were placed in the 3-4 holes of about 2 cm depth, around the root zone of each plant. The holes were closed after pouring the juveniles and slight watering was done. Each treatment was replicated three

times. Thus a total of 15 earthen pots were taken, including control, for the present study. The watering level, intensity of light and temperature were maintained during the course of experiments.

Culture of *M. incognita* in the Laboratory

The culture of ***M. incognita*** was maintained on tomato var. Pusa ruby in earthen pots of 20 cm diameter containing sterilised soil. These pots were inoculated with freshly hatched larvae from single egg mass and given the usual care. Periodic subculturing was done as and when necessary.

Measurements of various growth parameters

The plants were uprooted sixty days after inoculation and observations were recorded on various growth parameters **viz;** (1) shoot and root length, (2) total fresh and dry weight of shoot, (3) total fresh and dry weight of

root, (4) the number of leaves per plant, (5) number of fruits, (6) weight of fruits, (7) number of galls per plant, (8) second stage juvenile (J_2) population of root-knot nematodes in soil and (9) second stage juvenile (J_2) population of root-knot nematodes in root tissues.

The length of plant from base up to the growing tip were measured and considered as shoot length and rest of the length of plants was taken as root length. For determining the weight, each plant was cut at the base and weighed. The entire root system was first blotted gently between the fold of blotting paper and then weight was recorded.

Measurement of Nematode Populations in Soil

The determination of nematode population in soil was conducted by taking 50 gram of soil sample from each of the replicates, which were then processed using Cobb's modified sieving and Baermann's Funnel Technique (after Christie and Perry, 1951). The nematode suspensions

were taken out after 48 hrs. and the volume was made to 100 ml. One ml of the suspensions was transferred to a counting dish and nematodes were counted under a binocular stereoscopic microscope. An average of 3 counts were made to record the population. The total population of nematodes present in the soil sample was calculated.

Counting of Nematode Population in the Infested Root Tissues

After harvesting the plants, the nematodes population in roots was estimated by blenderizing 1 g of root sample from each replicate with the help of waring blender. For this purpose the tops of the plants were cut and the root system was removed carefully without any damage. Complete root system was washed through tap water and chopped into small pieces by means of a pair of scissors. One gram of chopped root pieces from each treatment was taken randomly and placed in a waring blender. 5 ml of tap water was added to it. The root was blenderized for one minute. The total blenderized

suspension was made up to 100 ml. One ml of this suspension was observed under binocular stereoscopic microscope for the presence of the number of eggs, second stage juveniles, spike tail stage, and adult males and females.

Studies on Penetration and Life Cycle of *M. incognita* on Okra

This experiment was conducted in small ice cream cups of 3 cm diameter to observe the penetration of second stage juveniles and their development in the root system of Okra. The ice cream cups were filled with 50 gm of steam sterilized sand. Two Okra seeds **var**, Pusa Sawani were sown in each cup. One seedling cup, however, was maintained after germination. Seven days' old seedlings were inoculated with 50 fresh hatched second stage juveniles of ***M. incognita*** near the root zones according to the procedure described in earlier experiment. The seedlings maintained at room temperature were exposed to 23° C day and 18° C night

temperatures. The observations on the penetration of second stage juveniles in the roots were recorded at regular interval of 12, 24, 36 and 48 hrs. after inoculation. Subsequently from second day onwards (**i.e.** after 48 hrs.) the observations were taken daily to determine the course of life cycle followed by the penetration of second stage juveniles upto the development of the adult stage. For recording each observation, three seedlings from ice cream cups were carefully uprooted, processed and stained using sodium hypochlorite and Fuchsin-glycerine method described by Byrd, Kirkpatrick, Barker (1983) as mentioned in the Foregoing text.

Staining Technique (after Byrd ***et al.***, 1983)

For each observation these infested seedlings were carefully removed from the ice cream cups. They were brought under slow running tap water after holding the seedlings in one hand. The root system was gently rubbed for 1 - 2 minutes to get rid of the adhered sand particles.

The roots were then immersed in 1.5 % NaOCl solution contained in a 150 ml beaker for 1 minute and agitated occasionally. Again the roots were immersed in clean tap water for overnight to remove the bleaching agent. After 24 hours, the roots were transferred for a minute into a beaker kept on a hot plate containing a boiling mixture of 30 ml of H_2O and 1 ml of stain (3.0 g acid Fuchsin + 250 ml acetic acid + 750 ml distilled water). The stained root system was again rinsed in tap water for 1 - 2 minutes to remove extra stain. Thereafter, the roots were cut off from the shoots, pressed between 2 -3 folds of blotting paper to absorb the extra water and finally kept in glass petri plates containing glycerine.

The sodium hypochlorite - Acid Fuchsin glycerine method was adopted for the experimental purpose, as it prevented the exposure of root material to the toxic phenols utilized in other staining methods. In addition, excessive stain of root was eliminated since the root tissue was bleeched with sodium hypochlorite prior to staining with Acid Fuchsin.

Characterization of "Resistant" and "Susceptible" Okra Varieties

10 varieties of Okra (***A. esculentus.)*** were tested for their susceptibility and resistance against ***M. incognita***. The test seeds of different varieties of Okra namely Pusa Sawani, Long green, Padra - 18–6, Dong - 10 ridged, 5 - Dhari, Spiny, White violet, Vaishakhi vadhu. Clemson spineless and Red were procured from the following Agricultural Institutes:-

1. Gujrat Agricultural University, Anand.
2. IARI, New Delhi.
3. G.B. Pant University of Agriculture and Technology, Pantnagar.
4. Acharya Narendra Dev University of Agriculture and Technology, Faizabad, U. P.

The procedure for introducing the inoculation in the pots was the same as mentioned in the preceding text in the first experiment. The inoculam level was 2000 second stage juveniles/Kg soil and 3 replicates of each variety

were tested in the inoculated and uninoculated pots. The cultivar Pusa Sawani is used for "susceptibility" check. The varieties are graded from "highly resistant" to "highly susceptible", based on the root-knot gall index rated on 0 – 5 scale of Sasser, Carter and Hartman (1984) as elaborated in the foregoing text.

Number of galls/plant	**Gall Index**	**Remarks**
0	0	Highly Resistant
1 - 25	1	Resistant
26 - 50	2	Moderately Resistant
51 - 75	3	Moderately Susceptible
76 - 100	4	Susceptible
More than 100	5	Highly Susceptible

Seed Treatment by Nematicides

The experiments were conducted for testing the efficacy of nematicides to control ***M. incognita*** infestations in Okra through seed treatment. The following six nematicides were used. Other details of nematicides are included in Table 1.

1.	Fensulphothion	5G
2.	Carbofuran	3G
3.	Aldicarb	10G
4.	Mocap	5G
5.	Phorate	10G
6.	Acephate	10G

The above nematicides are granular, contact and systemic nematicides. These non-fumigant and non volatile nematicides are comparatively less phytotoxic.

These can be applied before sowing on plants or even at standing plants. They are effective at much lower dosage. These are taken up by roots and translocated up in the plant system. The application of these nematicides does not require any special equipments.

Table1. The chemical composition and other details of chemicals used as seed and soil treatment against ***M. incognita*** infesting ***A. esculentus***

Common name	Alternative trade name	Chemical composition	Group
Fensulphothion 5G	Terracur P or Dasanit	0, 0 – diethyl – 0 (4-methyl Sulphinyl) monotheophosphate	Organophosphate
Carbofuran 3G	Furadan or Curatter	2, 3- dihydro – 2,2 di-methyl 7-benzofuranyl N-methyl carbomates	Carbamates
Mocap 5G	Ethoprop or Ethoprophos	0- ethyl 5, 5-dipro-pyl dithio phosphate	Organophosphate

Phorate 10G	Thimet	0, 0- diethyl - 5 (Ethyl-thiomethyl) dithiophosphate	Organophosphate
Aldicarb 10G	Temik	2 methyl - 2- (methyl-thio) Propionaldehyde -0-(Methyl Carbonyl) Oxime	Carbomates
Acephate 10G	Orthene	0-Methyl, 5-Methyl N-Acetyl Phospho-phoramidate	Organophosphate

Source of chemicals: Rallis India Ltd. Bangalore, Bharat Pulvarising Mills Pvt. Ltd. Bombay, FMC Carporation Ltd.

Each of the experimental pots was inoculated with 2000 J_2 /Kg soil of ***M. incognita***. After inoculation, the seeds treated with nematicides were sown in each pot. The above nematicides are tested in 3 different doses i.e. 1 %, 2% and 3% w/w.

For dressing Okra seeds with nematicides, gum is used as sticker. The nematicides were converted into powdered form. A paste was made by thoroughly mixing the require quantity of nematicides and gum plus 1 - 2 pinch of chalk powder on a piece of butter paper. Weighted quantity of seed already coated with the layer of gum was spread over and the stirred well with the help of a glass rod to attain a uniform coating of the nematicides over the seed testa. Seeds are then allowed to dry before sowing. In total there are 18 treatments (6 chemicals x 3 doses). Each treatment including one row of inoculated control was replicated three times.

Pre- (one day before sowing) and post-inoculation (two weeks after germination) soil treatment of plants

The nematicides listed above were used in the trials of pre- and post-inoculation soil treatments. Three different doses of these nematicides at the rate of 1, 2 and 4 Kg a. i. /ha were used. The required quantity of nematicides was thoroughly mixed with soil in segregated pots. Each pot was seeded with Okra as in previous experiments, and one week after germination of plant each pot was inoculated with freshly hatched 2000 J_2/Kg soil. The nematicides were applied in two split doses. In one type of treatment, nematicides were applied as pre-inoculation dose **i.e** one day before sowing of seeds. In the other type of treatment, the nematicides were applied one week after the inoculation **i.e.** post-inoculation soil treatment. Each treatment including one row of inoculated but untreated control were replicated three times.

Effect of nematicides, Neem cake and Urea used as soil treatment against *M. incognita* infesting *A. esculentus*

The combination of each of the three nematicides separately (1 and 2 Kg a. i./ha doses) with Neem cake (0.5 t/ha) and Urea (15 Kg/ha) were applied as soil treatment. Each of the pots were inoculated with 2000 J_2/Kg. One day after treatment of soil, the seeds of Okra cultivar Pusa Sawani sown. The details of different combinations of treatments used separately in segregated pot experiments follow. Each treatment was replicated thrice. Thus a total of 36 Earthen pots were used.

T1 = Neem cake 0.5 t/ha

T2 = Fensulphothion 1 Kg a. i. /ha+ Neem cake 0.5 t/ha

T3= Fensulphothion 1 Kg a i /ha+ Neem cake 0.5 t/ha + Urea 15 Kg/ha

T4= Fensulphothion 2 Kg a i./ha+ Neem cake 0.5 t/ha + Urea 15 Kg/ha

T5= Carbofuran 1 Kg a i /ha + Neem cake 0.5 t/ha

T6= Carbofuran 1 Kg a i /ha + Neem cake 0.5

t/ha + Urea 15 Kg/ha

T7 = Carbofuran 2 Kg a i. /ha + Neem cake 0.5 t/ha + Urea 15 Kg/ha

T8 = Mocap 1 Kg a i. /ha + Neem cake 0.5 t/ha

T9 = Mocap 1 Kg a i. /ha + Neem cake 0.5 t/ha + Urea 15 Kg/ha

T10 = Mocap 2 Kg a. i. /ha + Neem cake 0.5 t/ha + Urea 15 Kg/ha

T11 = Uninoculated and untreated control.

T12 = Inoculated but untreated control

Combined application of seed Treatments and soil treatment against *M. incognita* infesting Okra

The objective of this experiment was to utilise lesser concentration of nematicides in combined seed plus soil treatment applications. The inoculum comprised 2000

J_2/Kg soil in each of the pot. Nematicides (1 Kg a. i. /ha), Neem cake (0.5 t/ha) and Urea (15 Kg/ha) were applied in soil treatment. In the seed treatment the Okra seeds were treated with two doses **viz.** 1% w/w and 2% w/w of each of the four Nematicides in separate experiments. Three replicates of each treatment were arranged. The detailed combinations of different treatments are given below: -

T_1= Seed treatment with Phorate 1% w/w and soil treatment with Carbofuran 1 Kg a i. /ha +Neem cake 0.5 t/ha +Urea. 15 Kg/ha

T_2= Seed treatment with Phorate 2% w/w and soil treatment with Carbofuran 1 Kg a i. /ha +Neem cake 0.5 t/ha +Urea. 15 Kg/ha

T_3= Seed treatment with Carbofuran 1% w/w and soil treatment with Fensulphothion 1 Kg a. i. /ha + Neem cake0.5 t/ha + Urea 15 Kg/ha

T_4= Seed treatment with Carbofuran 2% w/w and soil treatment with Fensulphothion 1 Kg a i /ha + Neem cake 0.5 t/ha + Urea 15 Kg/ha

T_5= Seed treatment with Fensulphothion 1 % w/w and soil treatment with Mocap 1 Kg a i./ha +Neem cake 0.5 t/ha +Urea 15 Kg/ha

T_6= Seed treatment with Fensulphothion 2 % w/w and soil treatment with Mocap 1 Kg a i. /ha +Neem cake 0.5 t/ha +Urea 15 Kg/ha

T_7= Seed treatment with Mocap 1 % w/w and soil treatment with Phorate 1 Kg a. i. /ha +Neem cake 0.5 t/ha + Urea 15 Kg/ha

T_8= Seed treatment with Mocap 2 % w/w and soil treatment with Phorate 1 Kg a. i. /ha +Neem cake 0.5 t/ha + Urea 15 Kg/ha

T_9 = Uninoculated and untreated Control

T_{10} = Inoculated but untreated Control.

Statistical Analyses and Data Interpretation

According to Barker, Carter and Sasser (1985) the major part of nematological research has been concerned

primarily with the testing of hypothesis. The Analysis of Variance (ANOVA) leading to a test for difference among means has been the norm. Current trends in Statistics have, however, brought forward the estimation of effects, as opposed to simple hypothesis testing. Where appropriately done, the estimation of parameters with regression analysis, which lead to development of response model, will yield more accurate information than ANOVA. However the type of data analysed will determine appropriate procedures to be employed. Where treatments are qualitative in nature, such as different nematicides or cultivars, ANOVA and hypothesis testing are the only alternatives. Where treatments are quantitative, levels of a continuous variable, such as different rates of the same nematicides, regression analysis is appropriate. The information gained from analysis are compared as follows.

Comparison of information gained from hypothesis testing and parameters estimation

1. Hypothesis testing (ANOVA, test of mean):

a. Mean of treatments are/are not different.

b. A particular treatment mean different from another.

c. A particular group of treatment means differ from other groups.

2. Parameter Estimation: (Regression analysis)

a. Mathematical model for expected response of dependent variable (yield, number of nematodes etc.) to differing levels of treatment.

b. Expected response of dependent variable in the absence of treatment (Intercept of regression line).

c. Rate of response to increase or decrease in treatment levels (Slope).

d. Optimum rate of treatment (Maximum).

On the basis of aforementioned criteria, the regression analysis and analysis of variance (ANOVA), were employed. The regression analysis along with Coefficient of Correlation and t-test (Probability) were

employed to data obtained on various growth parameters under the influence of different doses of nemeticides. The comparisons were developed by the application of ANOVA and CD to data obtained from the results of experiments on varied treatments.

Student's 't' Test (Snedecor and Cochran, 1968):

$$t = \frac{r\sqrt{n-1}}{\sqrt{1-r^2}}$$

where,

r – correlation of correlation

n – number of samples

2. **Analysis of Variance (F)** (Snedecor and Cochran, 1968)

3. **Linear regression** (Snedecor and Cochran, 1968):

$$Y = \alpha_{yx} \quad \beta_{yx}.X$$

Where,

α_{yx}, Y - Intercept

β_{yx}, Slope predicting Y from X

4. Critical difference (CD)

The CD at 5% and 1% has been given where the results were found significant.

Skeleton of Analysis of Variance (Fischer, 1946)

Sources of Variance	d. f.	Sum of Square (S.S.)	Mean Sum of Square (MSS)	F_{cal}	F_{tab}
Replication	2				
Treatment	11				
Error	22				
Total	35				

Note: d. f. for treatments is different for different experiments = number of treatment – 1.

Thus, the significant differences between diffrent mean were judged by using critical difference (CD) at 5 %

and 1% level of significance, which were calculated as below.

$$CD = S.E_m \times \sqrt{2} \times t \text{ (at 5 \%)}$$

RESULTS

Inoculum Level Vis-À-Vis Growth Parameters Of A. *esculentus*

The observations recorded on the influence of different inoculum levels (0, 10, 100, 1000, 10000 J_2/pot) on ***A. esculentus*** revealed that the increase in root-knot nematode inoculum was associated with progressive reduction in various plant growth characters. The statistical analyses were based on Critical Difference (CD) and Coefficient of correlation on the basis of mean values of 3 replicates (presented in parentheses in the foregoing text) of ***A. esculentus.***

1. Effect on Shoot Length

The quantitative observations under the influence of ***M. incognita*** exhibited that significant reductions were found in shoot length at 1000 (24.00 cm) and 10000 J_2/pot (10.10 cm) over uninoculated control (37.20 cm). There was no significant difference at 10 J_2/pot (36.40 cm). The shoot length decreased at 100 J_2/pot (32.60 cm), but it was not significant statistically ($CD_{5\%}$= 4.81, $CD_{1\%}$= 7.0). The maximum reduction was seen at 10000 J_2/pot level where plants also showed

stunted appearance ($P < 0.05$) [Fig.1, Table 2] ($F_{2,4}$ = 58.90). The results of ANOVA are given in the foregoing text.

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	1538.25	384.564	58.9054	3.84
Replication	2	6.832	3.416		

SE = 2.086 $CD_{5\%}$= 4.819 $CD_{1\%}$= 7.009

2. Effect on Fresh Shoot Weight

The observations recorded on fresh shoot weight revealed that 10 and 100 J_2/pot inoculum level had no significant reduction (21.98 gm and 20.31 gm, respectively) over uninoculated control (22.15 gm). But the drastic reductions in fresh shoot weight were recorded at 1000 (14.30 gm) and 1000 J_2/pot (5.50 gm). The significant differences were observed at both the highest inoculum levels. The growth pattern were statistically significant CD $_{5\%}$= 3.67, CD $_{1\%}$= 5.34 ($P < 0.05$) [Fig.2, Table 2] ($F_{2,4}$ = 39.79). The results of ANOVA are presented below:-

Source	df	SS	MSS	F_{Cal}	F at 5%
Treatment	4	603.817	150.654	39.7977	3.84
Replication	2	1.119	0.5595		

SE = 1.590 $CD_{5\%}$= 3.673 $CD_{1\%}$= 5.343

3. Dry Shoot Weight

The data on dry shoot weight from plants that were subjected to 100 (8.35 g), 1000 (5.12 g) and 10000 J_2/pot (2.10 g) inoculum levels exhibited significant reduction over untreated controls (11.2 g). But 10 J_2/pot (10.4 g) did not showed any significant effect on the basis of $CD_{5\%}$= 3.08, $CD_{1\%}$= 4.48 ($P < 0.100$) [Fig.3, Table 2] ($F_{2,4}$ = 16.20). The results of ANOVA are as under:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	172.875	43.2188	16.2069	3.84
Replication	2	2.24788	1.12394		

SE = 1.333 $CD_{5\%}$= 3.080 $CD_{1\%}$= 4.480

4. Effect on Root length

The data subjected to statistical analysis showed that there was significant reduction at all inoculum levels over uninoculated control (35.10 cm). The reduction significantly increased at 10 (24.82 cm), 100 (21.10cm), 1000 (18.00cm) and 10,000 J_2/pot (5.20cm) levels. Though maximum reduction was observed at 10,000 J_2/pot level, but 100 J_2 and 1000 J_2 inoculum level were able to cause significant decrease in root length ($CD_{5\%}$ = 4.23 $CD_{1\%}$ = 6.15) ($P < 0.100$) [Fig.4 Table 2] ($F_{2,4}$ = 70.30). The results of ANOVA are as follows:-

Source	df	SS	MSS	F_{cal}	$F_{5\%}$
Treatment	4	1415.79	353.948	70.3053	3.84
Replication	2	9.33888	4.66944		

SE = 1.832 $CD_{5\%}$ = 4.232 $CD_{1\%}$ = 6.156

5. Effect on Fresh Root Weight

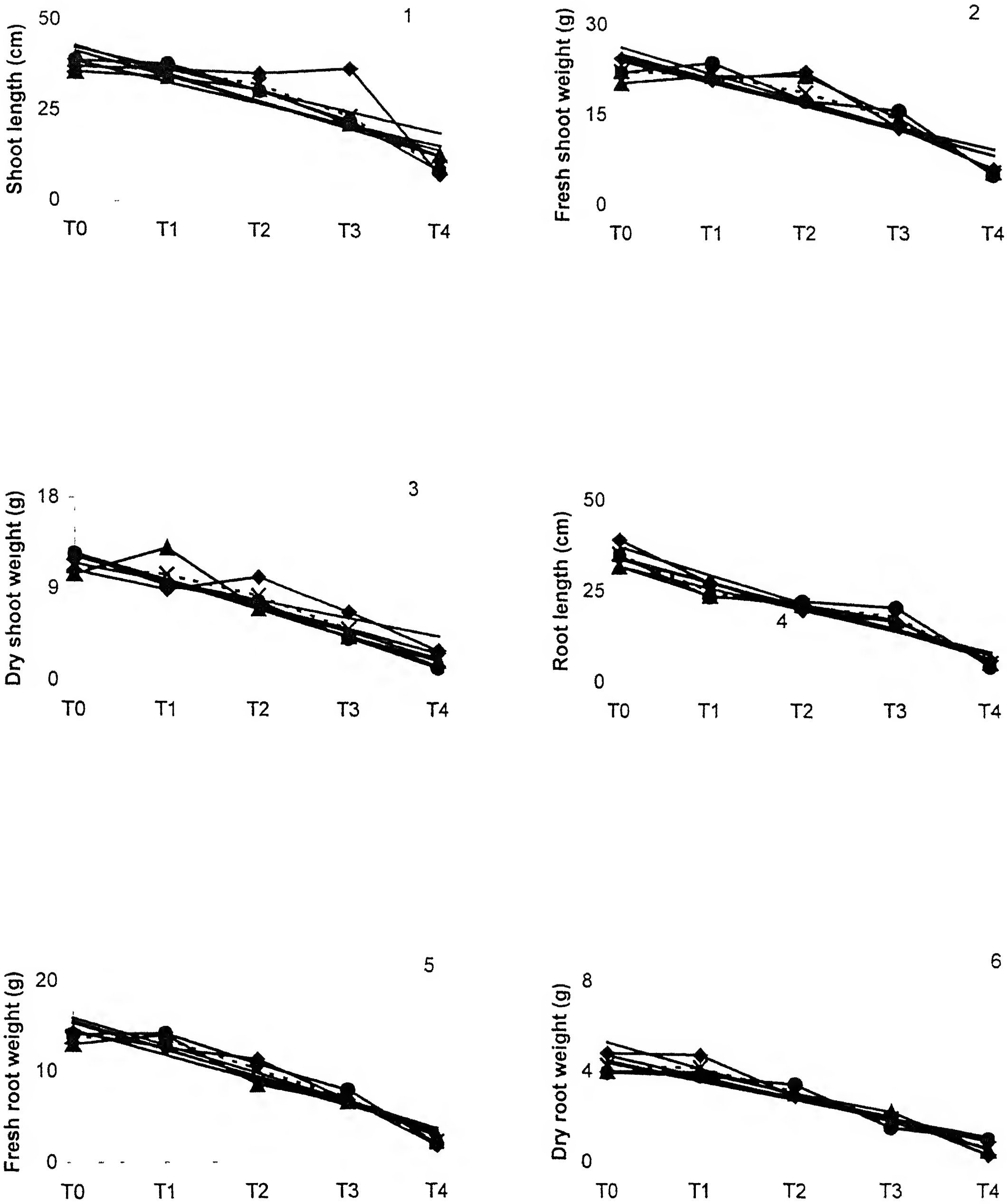
In case of root fresh weight the 10 J_2/pot inoculum level (13.60 g) did not show significant difference over uninoculated control (13.80 g). So 0 and 10 inoculum level were at par with each other. There were significant reductions in root weight recorded from experimental plants at 100 (10.20 g), 1000 (7.10 g) and

10000 J_2/pot (2.20 g) inoculum levels ($CD_{5\%}$= 2.31 $CD_{1\%}$ = 2.53) ($P < 0.100$) [Fig. 5, Table 2] ($F_{2,4}$ = 83.42). The results of ANOVA applications follow:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	284.304	71.076	83.4225	3.84
Replication	2	1.684	0.842		
SE = 0.753		$CD_{5\%}$ = 2.31		$CD_{1}\%$ = 2.532	

6. Effect on Dry Root Weight

The dry root weight was highly reduced, like other growth parameters, at 10000 J_2/pot (0.6 g). It was followed by 1000 (1.90 g) and 100 J_2/pot (3.10 g). The untreated control (4.25 g) and 10 J_2/pot (4.15 g) were almost at par in bio-statistical terms, with each other on the basis of $CD_{5\%}$=0.79 $CD_{1\%}$ = 1.16 ($P < 0.200$ - $P < 0.100$) [Fig. 6, Table 2] ($F_{2,4}$ = 40.46). The results of ANOVA are as follows:-


1
Shoot length (cm)
50
25
0
T0
T1
T2
T3
T4
2
Fresh shoot weight (g)
30
15
0
T0
T1
T2
T3
T4
3
Dry shoot weight (g)
18
9
0
T0
T1
T2
T3
T4
4
Root length (cm)
50
25
0
T0
T1
T2
T3
T4
5
Fresh root weight (g)
20
10
0
T0
T1
T2
T3
T4
6
Dry root weight (g)
8
4
0
T0
T1
T2
T3
T4

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	28.995	7.24875	40.4675	3.84
Replication	2	0.147	0.0735		

SE = 0.345 $CD_{5\%}$ = 0.798 $CD_{1\%}$ = 1.161

7. Effect on Number of Leaves

The total number of leaves in each replicate were counted. The data showed that 10 J_2/pot (5.66) and 100 J_2/pot (5.00) were almost at par with each other. A drastic reduction were observed at 1000 J_2/pot (3.33) and 10000 J_2/pot (0.66) inoculum level over uninoculated control (7.00). The data showed that there was gradual reduction in number of leaves at increased level of root-knot nematodes $CD_{5\%}$ =1.08 $CD_{1\%}$ = 1.58 ($P < 0.100$) [Fig. 7, Table 2] ($F_{2,4}$ = 53.5). The results of ANOVA are given in the foregoing text.

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	71.33333	17.833	53.5	3.84
Replication	2	3.333333	1.6666		

SE = 0.471 $CD_{5\%}$ = 1.088 $CD_{1\%}$ = 1.583

8. Effect on Number of Fruits

The bio-statistical evaluation of data on number of fruits by ANOVA ($F_{2,4}$ = 11.29) revealed highly significant growth pattern on the basis of $CD_{5\%}$ = 2.284 $CD_{1\%}$ = 3.322. A drastic reduction in the number of fruits (0.66) was recorded at 10000 J_2/pot inoculum level. The 1000 J_2/pot level also caused significant reduction (3.00) Though no significant difference was observed at 10 J_2/pot inoculum level (5.00) over uninoculated control (7.00)., yet a gradual decrease in the number and size of fruits were observed. The observations indicated that the fruits were comparatively smaller in size and poor in appearance ($P < 0.20$ - $P < 0.10$) at 1000 and 10000 J_2/pot inoculum levels [Fig.8 Table 2]. The results of ANOVA are given in the foregoing text.

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	66.266	16.566	11.295	3.84
Replication	2	0.933	0.466		

SE = 0.988 $CD_{5\%}$ = 2.284 $CD_{1\%}$ = 3.322

9. Effect on Weight of Fruits

The statistical analysis of data on fruit weight by ANOVA ($F_{2,4}$ = 622.74) indicated that 1000 (15.00 g) and 10000 J_2/pot (3.00 g) showed highly detrimental effect on weight of fruits. Although 10 (65.50 g) and 100 J_2/pot (60.40 g) did not show significant differences among each other in the weight of fruits, yet such reductions within the results of these 2 inoculums showed significant decrease over uninoculated control (91.10 g) on the basis of $CD_{5\%}$ = 4.82 $CD_{1\%}$ = 7.01 ($P < 0.20$) [Fig. 9, Table 2]. The results of ANOVA are as follows:-

Source	df	SS	MSS	F_{cal}	$F_{5\%}$
Treatment	4	16279.86	4069.96	622.747	3.84
Replication	2	4.516	2.258		

SE = 2.087 $CD_{5\%}$ = 4.821 $CD_{1\%}$ = 7.013

10. Effect on Number of Galls

The data on the number of galls under the influence of different inoculum levels by ANOVA ($F_{2,4}$ = 189.75) revealed highly significant growth pattern. There

was gradual increase in the number of root-knot galls with increasing level of nematodes in the following sequence:- Uninoculated control (0.00) < 10 J_2/pot (4.00) < 100 J_2/pot (47.00) < 1000 J_2/pot (108.00) < 10000 J_2/pot (257.00).

Only 10 J_2/pot inoculum did not exhibit significant difference over uninoculated control on the basis $CD_{5\%}$ = 25.24 $CD_{1\%}$ = 36.71 ($P < 0.05$) [Fig. 10, Table 2]. The results of statistical analysis by ANOVA are given as under:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	135980.4	33995.1	189.75	3.84
Replication	2	326.8	163.4		

SE = 10.929 $CD_{5\%}$ = 25.245 $CD_{1\%}$ = 36.720

11. Effect on Number of J_2 in 1ml Soil

The data on number of J_2 in 1ml soil revealed gradual increase in J_2 population with increasing level of inoculum. The 10 J_2/pot inoculum level (3.66) did not show significant difference over uninoculated control (0.00). But 100 (12.33), 1000 (17.00), 10000 J_2/pot (89.33) exhibited statistically significant increase in J_2

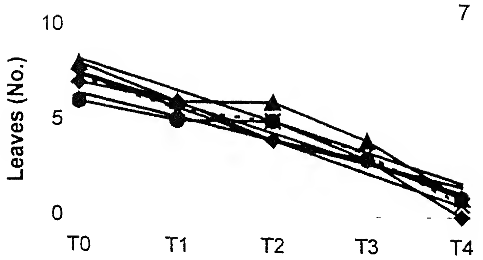
population on the basis of $CD_{5\%}$ = 3.23 and $CD_{1\%}$ = 4.69. There was drastic increase in the nematode (J_2) population observed at 10000 inoculum level ($P < 0.05$) [Fig. 2, Table 2] ($F_{2,4}$ = 1391.39). The results of ANOVA are as follows:-

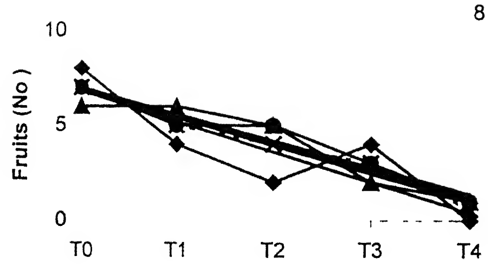
Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	16325.73	4081.43	1391.39	3.84
Replication	2	6.53333	3.26666		

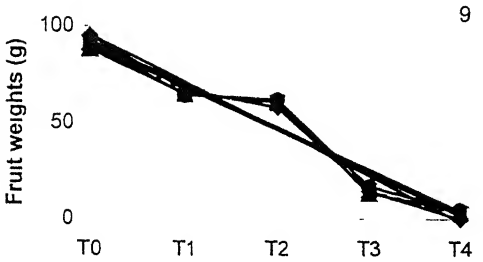
SE = 1.398 $CD_{5\%}$ = 3.230 $CD_{1\%}$ = 4.698

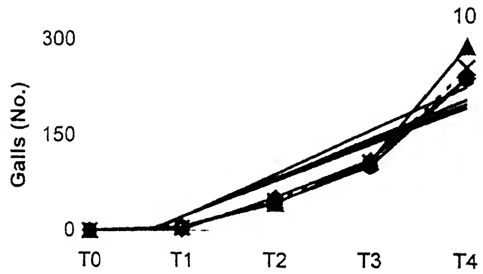
12. Effect on J_2 in Root

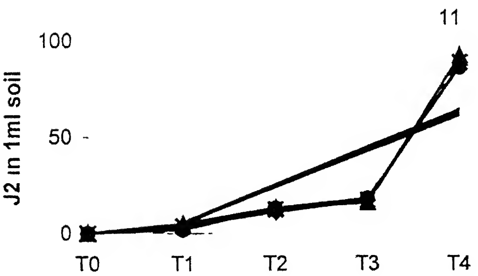
The data showed that the number of J_2 in roots of inoculated plants increased gradually with increase in inoculum level. The number of J_2 were increased significantly over untreated control (0.00) at 10000 (14.0) and 1000 J_2/pot (7.33), while 10 (2.33) and 100 J_2/pot (3.33) did not show any significant increase in number of J2 in the root of experimental plants as revealed by $CD_{5\%}$ = 2.15 $CD_{1\%}$ = 3.12 ($P < 0.10$ - $P < 0.05$) [Fig. 12, Table 2] ($F_{2, 4}$ = 69.53). The values of ANOVA are given in the foregoing text.

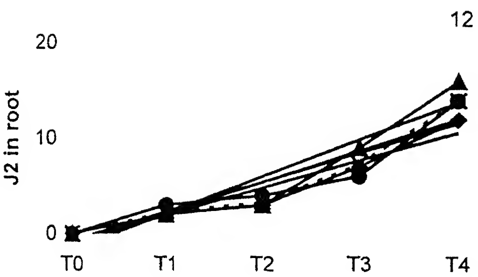

7
Leaves (No.)
10
5
0
T0
T1
T2
T3
T4


8
Fruits (No)
10
5
0
T0
T1
T2
T3
T4


9
Fruit weights (g)
100
50
0
T0
T1
T2
T3
T4


10
Galls (No.)
300
150
0
T0
T1
T2
T3
T4


11
J2 in 1ml soil
100
50
0
T0
T1
T2
T3
T4


12
J2 in root
20
10
0
T0
T1
T2
T3
T4

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	4	361.6	90.4	69.5384	3.84
Replication	2	3.6	1.8		

SE = 0.930 $CD_{5\%}$ = 2.150 $CD_{1\%}$ = 3.127

Table 2 : Linear regression trends depicting effect of different inoculum level (0, 10, 100, 1000, 10000 J_2) of ***M. incognita*** on ***A. esculentus***.

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 36.062 – 0.00027 X	r = - 0.778	$P < 0.05^S$
	R_2	Y = 31.963 – 0.00023 X	r = - 0.672	$P < 0.200^S$
	R_3	Y = 31.5037 – 0.00018 X	r = - 0.698	$P < 0.100^S$
	Mean	Y = 33.39 – 0.00023 X	r = - 0.740	$P < 0.05^S$
Fresh Shoot weight	R_1	Y = 20.59 – 0.00015 X	r = - 0 696	$P < 0.100^S$
	R_2	Y = 20.14 – 0.00015 X	r = - 0.739	$P < 0.05^S$
	R_3	Y = 19.86 – 0.00014 X	r = - 0.752	$P < 0.05^S$
	Mean	Y = 19.73 – 0.00014 X	r = - 0.741	$P < 0.05^S$
Dry Shoot weight	R_1	Y = 9.404 – 0 0006 X	r = - 0.729	$P < 0.100^S$
	R_2	Y = 8.737 – 0.0007 X	r = - 0.629	$P < 0.200^S$
	R_3	Y = 9.00 – 0.0007 X	r = - 0.583	$P < 0.200^S$
	Mean	Y = 9.05 – 0.0007 X	r = - 0.669	$P < 0.100^S$
Root length	R_1	Y = 26.47 – 0.00021 X	r = - 0.604	$P < 0.200^S$
	R_2	Y = 25.86 – 0.00022 X	r = - 0.706	$P < 0.100^S$
	R_3	Y = 24.09 – 0.00019 X	r = - 0.695	$P < 0.100^S$
	Mean	Y = 25.47 – 0.00020 X	r = - 0 671	$P < 0.100^S$
Fresh Root weight	R_1	Y = 11.62 – 0.00016 X	r = - 0.705	$P < 0.100^S$
	R_2	Y = 12.12 – 0.00010 X	r = - 0.718	$P < 0.100^S$
	R_3	Y = 10.84 – 0.0008 X	r = - 0.635	$P < 0.100^S$
	Mean	Y = 11 53 – 0.0009 X	r = - 0.695	$P < 0.100^S$
Dry Root weight	R_1	Y = 3.73 – 0.0003 X	r = - 0.659	$P < 0.100^S$
	R_2	Y = 3.28 – 0.0002 X	r = - 0.612	$P < 0.200^S$
	R_3	Y = 3.36 – 0.0001 X	r = - 0.629	$P < 0.100^S$
	Mean	Y = 3.46 – 0.0002 X	r = - 0.673	$P < 0.100^S$
Leaves (No.)	R_1	Y = 5.11 – 0.00023 X	r = - 0.444	$P > 0.50^{NS}$
	R_2	Y = 4.89 – 0.0004 X	r = - 0.707	$P < 0.100^S$
	R_3	Y = 6.19 – 0.0005 X	r = - 0.707	$P < 0.100^S$
	Mean	Y = 5.47 – 0.0004 X	r = - 0.677	$P < 0.100^S$
Fruits (No)	R_1	Y = 4.64 – 0.0004 X	r = - 0.551	$P < 0.200^S$
	R_2	Y = 5.16 – 0.0004 X	r = - 0.664	$P < 0.100^S$
	R_3	Y = 4.12 – 0.0004 X	r = - 0.622	$P < 0.200^S$
	Mean	Y = 4.91 – 0.0004 X	r = - 0.657	$P < 0.100^S$

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Fruit weight	R_1	Y = 61.51 – 0.0006 X	r = - 0.587	$P < 0.200^S$
	R_2	Y = 61.66 – 0.0006 X	r = - 0.589	$P < 0.200^S$
	R_3	Y = 59.51 – 0.0005 X	r = - 0.576	$P < 0.200^S$
	Mean	Y = 60.69 – 0.0006 X	r = - 0.584	$P < 0.200^S$
Galls (No.)	R_1	Y = 34.15 + 0.0002 X	r = 0.740	$P < 0.05^S$
	R_2	Y = 31.04 + 0.0002 X	r = 0.755	$P < 0.05^S$
	R_3	Y = 30.82 + 0.0002 X	r = 0.768	$P < 0.05^S$
	Mean	Y = 31.63 + 0.0002 X	r = 0.762	$P < 0.05^S$
J_2 in 1ml soil (No.)	R_1	Y = 5.61 + 0.0008 X	r = 0.795	$P < 0.05^S$
	R_2	Y = 5.87 + 0.0008 X	r = 0.791	$P < 0.05^S$
	R_3	Y = 6.03 + 0.0008 X	r = 0.794	$P < 0.05^S$
	Mean	Y = 5.81 + 0.0008 X	r = 0.794	$P < 0.05^S$
J_2 in Root	R_1	Y = 2.64 + 0.0009 X	r = 0.711	$P < 0.100^S$
	R_2	Y = 2.88 + 0.0001 X	r = 0.750	$P < 0.05^S$
	R_3	Y = 3.01 + 0.0001 X	r = 0.721	$P < 0.100^S$
	Mean	Y = 2.82 + 0.0001 X	r = 0.732	$P < 0.05^S$

Penetration and life cycle of *M. incognita* on *A. esculentus*

Experimental observations recorded on the penetration of J_2 in roots and the life cycle of ***M. incognita*** on ***A. esculentus*** are described as follows:

1. Penetration of J_2 in Roots

The data recorded on the penetration studies (Table 3) indicated that the infective J_2 started invading the young roots of ***A. esculentus***, within 12 hours after inoculation. By this time, 14% of J_2 had already invaded the roots. Maximum penetration of J_2 into the host occurred at the growing tips within the region of cell enlargement and differentiation. Subsequently there was a gradual increase in the penetration rate to 46% and 61% after 24 and 36 hours of inoculation respectively. However, maximum penetration rate of 70.00 percent was recorded at 48 hours after inoculation (Table 3).

2. Life Cycle

As mentioned in Materials and Methods, the observations for the penetration studies were carried out

till second day after inoculation at a regular interval of 12 hours.

Thereafter, from the second day onwards (48 hours after inoculation), the observations for various developmental stages were recorded after every 24 hours, till the completion of life cycle. It was observed that the infective second stage juveniles, which invaded the roots after 12 hrs. inoculation, remained vermiform in the roots for approximately 6 days following inoculation. After penetrating through the meristematic tissues, the movement of J_2 was both intercellular and intracellular. The feeding of nematodes resulted in hypertrophy, hyperplasia and giant cell formation in tissue immediately surrounding the heads of the nematodes. By 10th day of inoculation the 2nd moult occurred and J_2 became sedentary, non-feeding and reached the spike-tail stage. The 3rd moult occurred between 10th and 16th day after inoculation. By this time (16th day after inoculation) the juveniles were still non-feeding and gradually enlarged to acquire a globost pre-adult stage. Thereafter, by the 21st day of inoculation the 4th and final moult from pre-adult to adult female and male occurred. The adult females

were found feeding in cortex, endodermis, pericycle and stele region of the roots. A few male nematodes were also recorded by this time. Oviposition occurred after 26 days of inoculation, when the first egg mass was noticed attached to root-knot galls. The life cycle completion occurred by 33rd day (Table 4), when the first hatched J_2 from the eggs masses was found in the infected root tissue thereby indicating the start of 2nd generation.

Table 3. Studies on penetration of J_2 in Roots of *A. esculentus.*

Hours after Inoculation	Number of J_2 Penetrated	Percent penetration
12	7.00	14.00
24	23.00	46.00
36	30.66	61.32
45	35.33	70.66

(Average of 3 Replications)

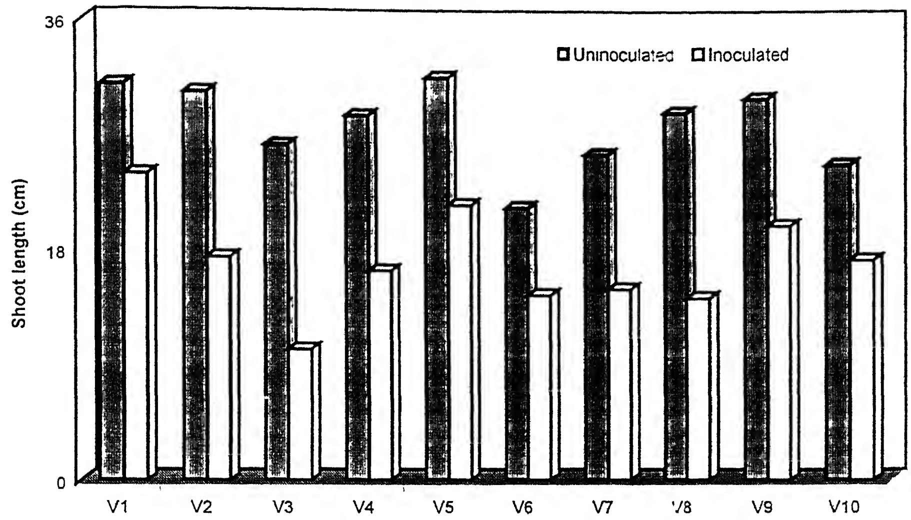
Table 4. Studies on the life cycle of *M. incognita* on *A. esculentus.*

Stage appeared	Days after inoculation
J_2	8
J_3	10
J_4	16
Young male and female	21
Oviposition	26
J_2 second generation	33

Studies On Screening Of *A. esculentus* Varieties For Their Resistance Against *M. incognita*

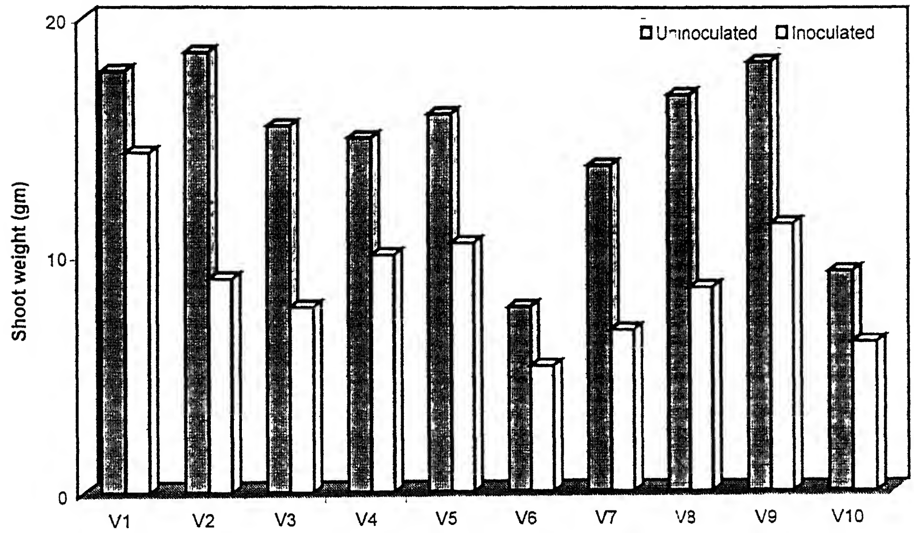
After counting the total number of root-knot galls in each variety [Fig. 18], these were graded on the root-knot index ranging from 0 to 5 [Fig. 17]. The patterns of different growth parameters in each of these varieties in response to *M. incognita* infection are shown in Figs. 13 - 18.

Out of the total of ten varieties tested for their resistance against *M. incognita,* none of these could be categorized as "highly resistant", "resistant" or "moderately resistant" varieties. Three varieties **i.e.** Spiny, Red and Clemson spineless were found to be "moderately susceptible" with root gall index ranging about 3 [Fig. 17]. The shoot length and weight was highly reduced in Clemson spineless than the other two varieties [Figs. 13, 14]. Five varieties **i.e.** Pusa Sawani, Long green, 5-dhari, Vaishakhi Vadhu and White violet were susceptible with root-knot index about 4. In 5-dhari and Vaishakhi Vadhu, the shoot and root lengths were comparatively more reduced due to root-knot nematodes. The remaining two varieties **viz.** Padra-18-6, and Dong-



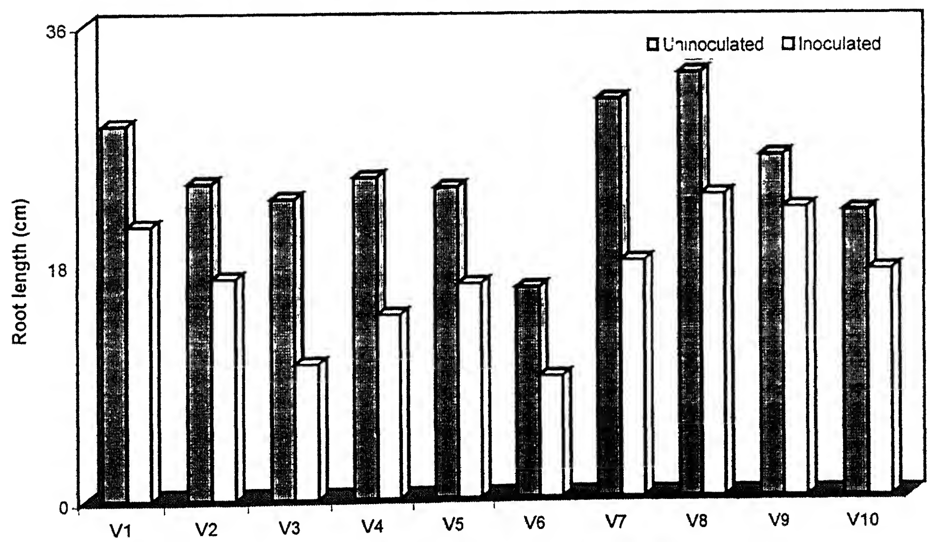
36
18
0
Shoot length (cm)
Uninoculated
Inoculated
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

13



20
10
0
Shoot weight (gm)
Uninoculated
Inoculated
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

14



36
18
0
Root length (cm)
Uninoculated
Inoculated
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

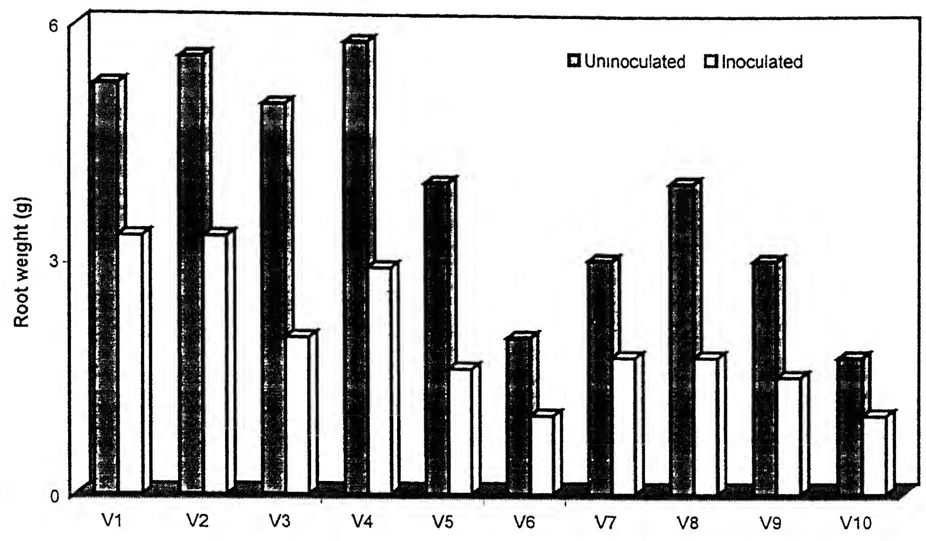
15

10 ridged were "highly susceptible" with root-knot index upto 5. The shoot and root length, and shoot and root weight were highly reduced in Padra - 18 - 6 [Figs. 13-16].

The data on the number of galls in the three replicates of different varieties of ***A. esculentus*** subjected to statistical analysis by ANOVA ($F_{2,4}$ = 24.13) showed that Padra -18 - 6 (128.33) and Dong-10 ridge (124.00) varieties were highly susceptible, while Clemson spineless had lowest susceptibility among all the ten varieties. Pusa Sawami (82.00) Long green (82.67) and Vaishakhi Vadhu (80.00) were almost at par with each other in their levels of susceptibility. Spiny (74.00) and Red (75.00) varieties were also similar in their susceptibility against ***M. incognita*** (C.D.$_{5\%}$ = 12.53 $CD_{1\%}$ = 17.19). The level of significance revealed by ANOVA is given as under: -

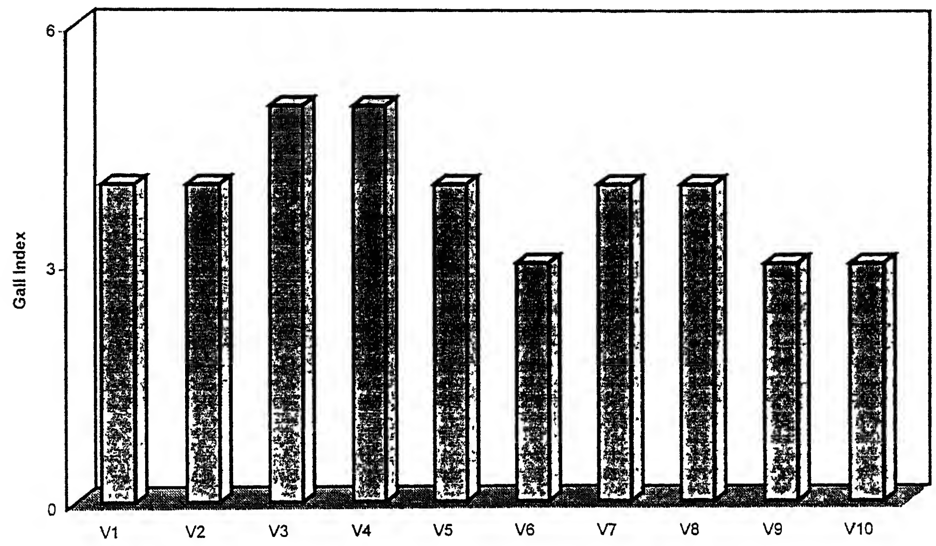
Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	11619.47	1291.052	24.13849	2.51
Replication	2	1683.267	841.6333		

SE = 5.971 $CD_{5\%}$ = 12.59 $CD_{1\%}$ =17.197



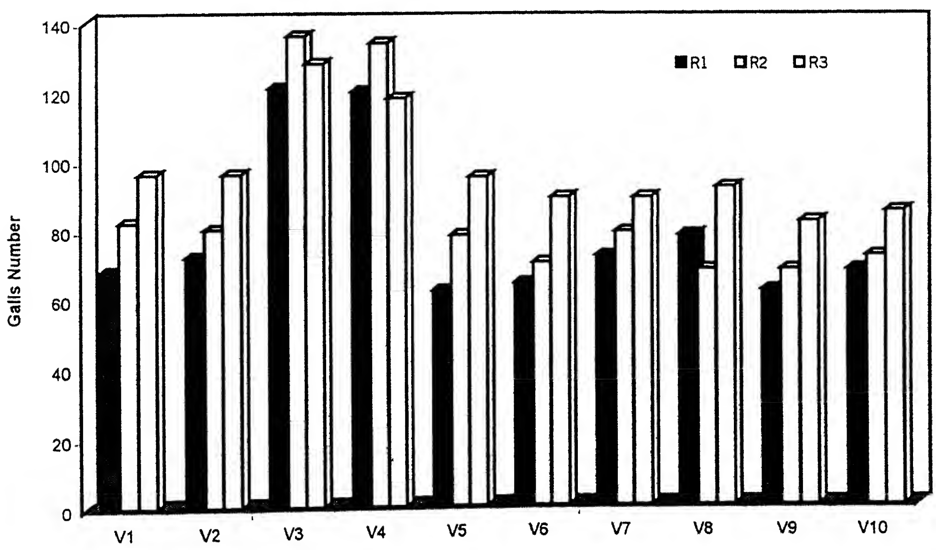
Uninoculated
Inoculated
Root weight (g)
6
3
0
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

16



Gall Index
6
3
0
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

17



R1
R2
R3
Galls Number
140
120
100
80
60
40
20
0
V1
V2
V3
V4
V5
V6
V7
V8
V9
V10

18

Studies On Effect Of Nematicides Used As Seed Treatment Against *M. incognita* Infesting *A. esculentus*

The data pertaining to the effect of different nematicides used as seed treatment in three dosages (1%, 2%, 3% w/w) on different growth parameters of the experimental plants were analysed and have been dealt with separately as under.

A. Effect of Fensulphothion

1. Effect on Shoot Length

The maximum growth of shoot was encountered in R_3 replicates than the other two at 3% dosage, while minimum growth was recorded in R_2 replicates at 1% dosage. The growth pattern, however, was significant ($P < 0.20 - P < 0.10$) in this experiment [Fig. 19, Table 5].

2. Effect on Shoot Weight

The shoot weight of the experimental plants exhibited significant variation under the influence of

Fensulphothion with maximum growth at 3% dosage in all the replicates **i.e.** R_1, R_2 and R_3. Minimum growth was recorded in R_2 replicates at 2% dosage. Overall growth was statistically significant ($P < 0.20$ – $P < 0.10$) [Fig. 20, Table 5].

3. Effect on Root Length

The maximum growth of root was recorded at 3% dosage in R_1 and R_3 replicates, while minimum growth was observed in R_2 replicates at 1% dosage. The level of significance was, however, uniform ($P < 0.10$) [Fig. 21, Table 5].

4. Effect on Root Weight

The weight of root of experimental plants exhibited maximum growth at 3% dosage in R_1 and R_3 replicates, while minimum growth occurred at 1% dosage in R_2 replicates ($P < 0.10$) [Fig. 22, Table 5].

5. Effect on Number of Leaves

In the quantitative estimation of the efficacy of nematicides resulting into divergent number of leaves in potted plants maximum numbers were recorded in R_3 replicates at 3% dosage. But wide variations occurred in

R_2 replicates with minimum number at 1% dosage. The growth pattern was statistically significant ($P < 0.10$) [Fig. 23, Table 5].

6. Effect on Fruits Number

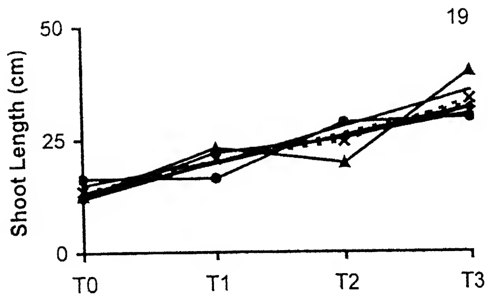
The maximum number of fruits were recorded at 3% dosage in R_3 replicates, while minimum number were observed in R_2 at 1% dosage. The dosage in R_1, however, was not effective than control plant group at 1% and 2% doses but 3% dosage was significantly effective to increase the number of fruits ($P < 0.10$) [Fig. 24, Table 5].

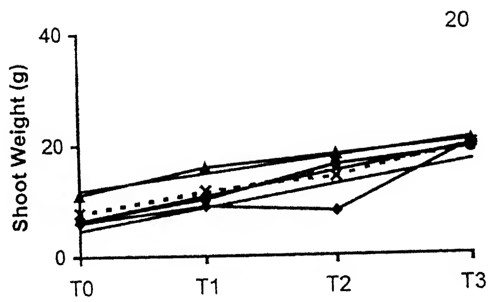
7. Effect on Weight of Fruits

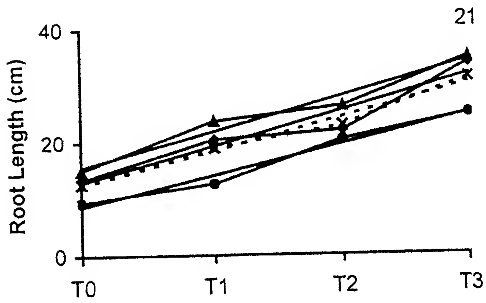
The weight of fruits of experimental plants was maximum in R_3 replicates at 3% dosage, while it was minimum in R_2 at 1% dosage. In R_1 replicates, the efficacy of 1% and 2% doses exhibited equal potential. Overall growth, was statistically significant ($P < 0.20 - P < 0.10$) [Fig. 25, Table 5].

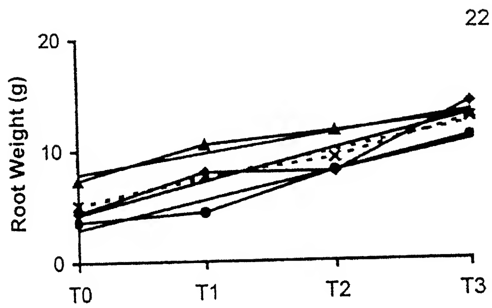
8. Effect on Number of Root-Knot Galls

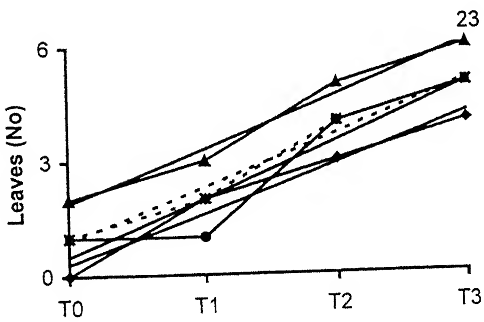
The maximum reduction in the number of galls was recorded at 3% dosage in all the replicates **i.e.** R_1, R_2

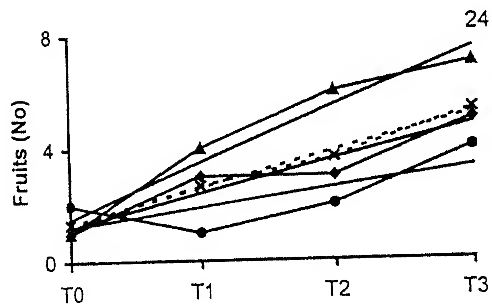

19
Shoot Length (cm)
50
25
0
T0
T1
T2
T3

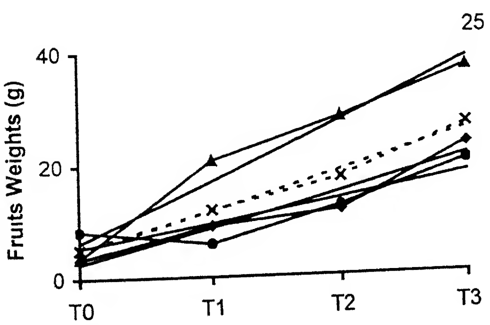

20
Shoot Weight (g)
40
20
0
T0
T1
T2
T3


21
Root Length (cm)
40
20
0
T0
T1
T2
T3


22
Root Weight (g)
20
10
0
T0
T1
T2
T3


23
Leaves (No)
6
3
0
T0
T1
T2
T3


24
Fruits (No)
8
4
0
T0
T1
T2
T3


25
Fruits Weights (g)
40
20
0
T0
T1
T2
T3

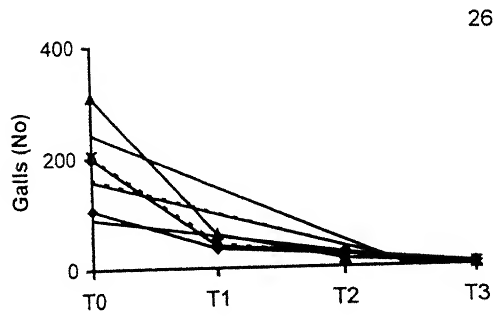

26
Galls (No)
400
200
0
T0
T1
T2
T3

Table 5 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Fensulphothion (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 13.32 + 6.32 X	r = 0.735	$P < 0.100^S$
	R_2	Y = 14.85 + 5.35 X	r = 0.686	$P < 0.200^S$
	R_3	Y = 11.91 + 8.01 X	r = 0.658	$P < 0.200^S$
	Mean	Y = 13.36 + 6.55 X	r = 0.741	$P < 0.100^S$
Shoot weight	R_1	Y = 4.60 + 4.1 X	r = 0.630	$P < 0.200^S$
	R_2	Y = 6.41 + 4.38 X	r = 0.742	$P < 0.100^S$
	R_3	Y = 11.83 x 3.03 X	r = 0.731	$P < 0.100^S$
	Mean	Y = 7.61 + 3.84 X	r = 0.740	$P < 0.100^S$
Root length	R_1	Y = 12.94 + 6 34 X	r = 0.717	$P < 0.100^S$
	R_2	Y = 8.66 + 5 46 X	r = 0.741	$P < 0.100^S$
	R_3	Y = 15.61 + 6 28 X	r = 0.736	$P < 0.100^S$
	Mean	Y = 12.40 + 6 03 X	r = 0.743	$P < 0.100^S$
Root weight	R_1	Y = 4.12 + 3 12 X	r = 0.695	$P < 0.100^S$
	R_2	Y = 2.89 + 2.59 X	r = 0.730	$P < 0.100^S$
	R_3	Y = 7 85 + 1.82 X	r = 0.727	$P < 0.100^S$
	Mean	Y = 5.00 + 2.44 X	r = 0.742	$P < 0.100^S$
Leaves (No.)	R_1	Y = 0.30 + 1.3 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 0.50 + 1.5 X	r = 0.704	$P < 0.100^S$
	R_3	Y = 1.9 + 1.4 X	r = 0.742	$P < 0.100^S$
	Mean	Y = 0.90 + 1.4 X	r = 0.742	$P < 0.100^S$
Fruits (No)	R_1	Y = 1.2 + 1.2 X	r = 0 711	$P < 0.100^S$
	R_2	Y = 1.2 + 1 7 X	r = 0.538	$P < 0.200^S$
	R_3	Y = 1.5 + 2.0 X	r = 0.731	$P < 0.100^S$
	Mean	Y = 1.2 + 1 3 X	r = 0.746	$P < 0.100^S$
Fruit weight	R_1	Y = 2.58 + 6.13 X	r = 0.720	$P < 0.100^S$
	R_2	Y = 5.41 + 4.16 X	r = 0.651	$P < 0.200^S$
	R_3	Y = 6.28 + 10.67 X	r = 0.734	$P < 0.100^S$
	Mean	Y = 4.75 + 6.98 X	r = 0.746	$P < 0.100^S$
Galls (No.)	R_1	Y = 88.7 - 31.3 X	r = -0.690	$P < 0\ 200^S$
	R_2	Y = 157.4 - 60.1 X	r = -0.649	$P < 0.200^S$
	R_3	Y = 242 - 97 X	r = -0.649	$P < 0.200^S$
	Mean	Y = 162.7 -62.8 X	r = -0.656	$P < 0.200^S$
J2 in 1ml soil (No.)	R_1	Y = 18.8 -6.7 X	r = -0.698	$P < 0.100^S$
	R_2	Y = 18.6 -4.9 X	r = -0.678	$P < 0.200^S$
	R_3	Y = 28.2 -9.8 X	r = -0.724	$P < 0.100^S$
	Mean	Y = 21.8 -7.2 X	r = -0.726	$P < 0.100^S$

and R_3, while minimum reduction occurred in R_2 replicates at 1% dosage ($P < 0.20$) [Fig. 26, Table 5]. However, comparative data on dose efficacy revealed steep decline in R_3 replicates, followed by R_2 replicates when the first application of 1% dosage was conducted. Thereafter, the decline at 2% and 3% dosage was not so remarkable. Therefore, the effect of nematicides was more marked between dosages than between replicates.

9. Effect on Number of J_2 in 1ml soil

The quantitative assessment of the number of J_2 (second stage juvenile larva) **vis-a-vis** dosage variation revealed maximum reduction in R1 replicates at 3% dosage. The varied response of R_2 replicates to different doses revealed immediate initial decline at 1% dosage but gradually J_2 larvae could emerge resistant and resultantly exhibited severe decline in J_2 larvae thereafter at high dose of 3%. The effect of Fensulphothion in the reduction of J_2 was statistically significant ($P < 0.20$ - $P < 0.10$) [Fig. 27, Table 5].

B. Effect of Carbofuran

1. Effect on Shoot Length

The experiments dealing with seeds of *A. esculentus* treated with different doses of Carbofuran exhibited maximum growth in shoot length of the potted plants in R_1 replicates at 3% dosage. But the growth in shoot length was minimal in R_3 replicates at 1% dosage ($P < 0.10$) [Fig. 28, Table 6].

2. Effect on Shoot Weight

The fresh weight of shoot of experimental plants exhibited significant variations at 2% and 3% dosage with maximum growth achieved in R_1 replicate at 3%, while minimum growth was recorded in R_3 replicate at 2% dosage ($P < 0.20$ – $P < 0.10$) [Fig. 29, Table 6].

3. Effect on Root Length

The linear regression trends confirmed increased efficacy of dosages of higher strength ranging gradually from 1% to 3%. The maximum growth occurred in R_1 replicate at 3% dosage, while minimum growth was encountered in R_2 replicate at 1 % dosage ($P < 0.10$) [Fig. 30, Table 6].

4. Effect on Root Weight

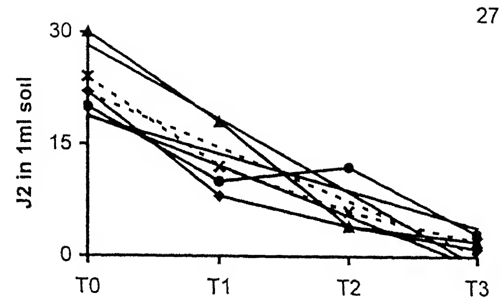
The R_1 and R_2 replicates of experimental plants exhibited maximum growth at 3% dosage and minimum growth at 1 % dosage in R_1 replicate. There was wide variation in R_3 replicates at different dosages and marginal decline in growth was recorded at 2% dosage. The growth patterns, however, were statistically significant ($P < 0.10$) [Fig. 31, Table 6].

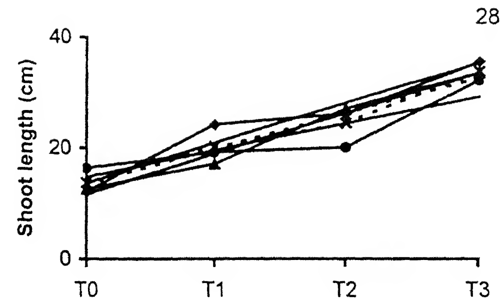
5. Effect on Number of Leaves

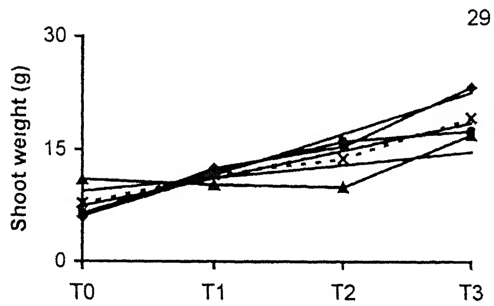
The number of leaves in experimental plants were highest at 3% dosage in R_1 replicate, while it was minimum at 1% dosage in R_1 replicates. ($P < 0.10$) [Fig. 32, Table 6]. The linear regression patterns confirmed the increased efficacy of dosages as the increase in the number of leaves from 1% to 3% was encountered.

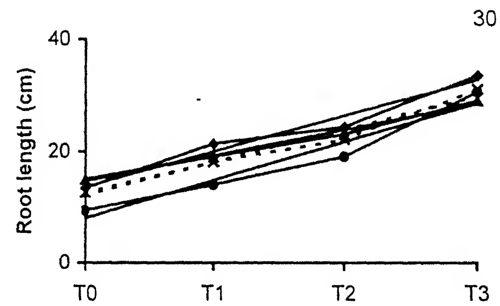
6. Effect on Number of Fruits

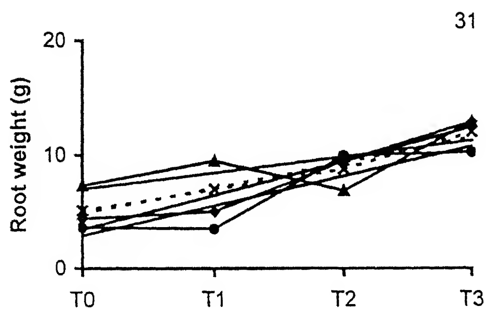
The maximum number of fruits were recorded at 2% dosage in R_2 replicates, which was at par with those obtained at 3% dosage in R_1 replicates. This would mean that the fruit production power of plants became susceptible to the toxic influence of Carbofuran in R_2

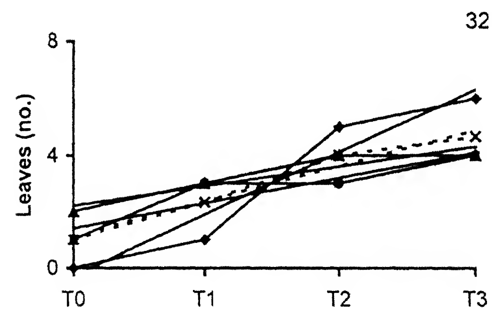

27
J2 in 1ml soil
30
15
0
T0
T1
T2
T3

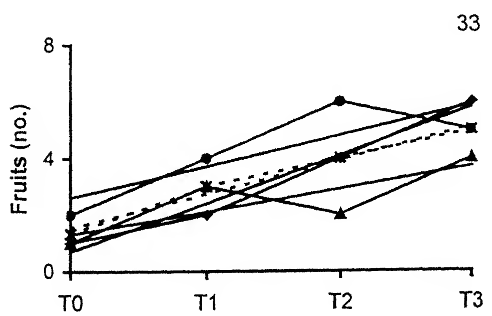

28
Shoot length (cm)
40
20
0
T0
T1
T2
T3

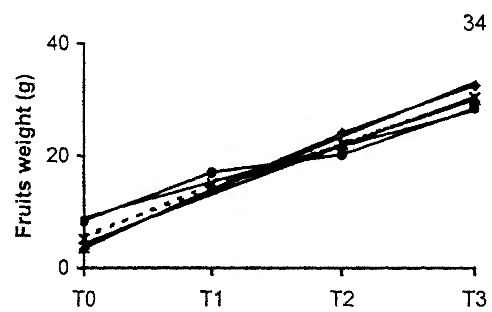

29
Shoot weight (g)
30
15
0
T0
T1
T2
T3


30
Root length (cm)
40
20
0
T0
T1
T2
T3


31
Root weight (g)
20
10
0
T0
T1
T2
T3


32
Leaves (no.)
8
4
0
T0
T1
T2
T3


33
Fruits (no.)
8
4
0
T0
T1
T2
T3


34
Fruits weight (g)
40
20
0
T0
T1
T2
T3

replicates at higher dosage (3%), while the same nematicide exhibited gradual increased growth in R_1 replicates, when the treatment strength was increased from 1% to 3%. The minimum number of fruits were encountered in R_3 replicate at 2% dosage. The growth patterns were, however, statistically significant ($P < 0.20$ – $P < 0.10$) [Fig. 33, Table 6].

7. Effect on Weight of Fruits

Linear regression trends confirmed that the pattern on the increase in fruits weight of ***A. esculentus*** did not show significant variation among 3 replicates **viz.** R_1, R_2 & R_3, in potted plant, while comparable efficacy of 3 dosage of nematicides were tested. ($P < 0.10$) [Fig. 34, Table 6]. But apparently all the dosages of Carbofuran (1%, 2% and 3%) had detrimental effect on nematode (nemic) population because the minimum weight of fruits was encountered in plants that were not treated by any of the nematicides.

8. Effect on Number of Galls :

The number of galls in the roots of ***A. esculentus*** exhibited minimum number of galls at 3%

dosage on application of 3 dosages within R_1, R_2 and R_3 replicates in potted plants. The lowest efficacy was of 1 % dosage, out of the three doses [Fig. 35, Table 6]. Interestingly sudden declining effect of nematicide was apparent at 1 % dosage on R_3 replicates.

9. Effect on Number of J_2 In 1ml Soil

The number of second stage juveniles (J_2) in soil was highly reduced at 3% dosage in all the replicates, R_1, R_2 and R_3 of ***A. esculentus***. There was sharp decline in number of J_2 in R_3 replicate at 1% dosage. Minimum reduction was recorded at 1% dosage in R_2 replicates. Linear regression pattern confirmed significant reduction in the number of J_2 population ($P < 0.20 - P < 0.10$) [Fig. 36, Table 6].

C. Effect of Mocap

1. Effect on Shoot Length

The length of shoot of ***A. esculentus*** under the influence of 3 dosages with R_1, R_2 and R_3 replicates exhibited no significant variations. The linear regression patterns showed statistically significant increase, with the peak attained at 3% dosage than the lower two dosages.

Table 6 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Carbofuran (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 13.56 + 7.24 X	r = 0.725	$P < 0.100^S$
	R_2	Y = 14.65 + 4.82 X	r = 0.668	$P < 0.200^S$
	R_3	Y = 11 55 + 7.3 X	r = 0.742	$P < 0.100^S$
	Mean	Y = 13.25 + 6.45 X	r = 0.741	$P < 0.100^S$
Shoot weight	R_1	Y = 6.06 + 5.51 X	r = 0.739	$P < 0.100^S$
	R_2	Y = 7.43 + 3.73 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 9.42 + 1.77 X	r = 0.517	$P < 0.200^S$
	Mean	Y = 7.62 + 3.67 X	r = 0.740	$P < 0.100^S$
Root length	R_1	Y = 13.63 + 6.33 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 7.98 + 6.83 X	r = 0.728	$P < 0.100^S$
	R_3	Y = 14.6 + 4.6 X	r = 0.745	$P < 0.100^S$
	Mean	Y = 12.07 + 5.92 X	r = 0.739	$P < 0.100^S$
Root weight	R_1	Y = 3 43 + 3.03 X	r = 0.724	$P < 0.100^S$
	R_2	Y = 4.06 + 2.36 X	r = 0.719	$P < 0.100^S$
	R_3	Y = 6.99 + 1.45 X	r = 0.502	$P < 0.200^S$
	Mean	Y = 4.83 + 2.28 X	r = 0.741	$P < 0.100^S$
Leaves (No.)	R_1	Y =0 30 + 2.2 X	r = 0.723	$P < 0.100^S$
	R_2	Y = 1.4 + 0 9 X	r = 0.692	$P < 0.100^S$
	R_3	Y = 2.2 + 0.7 X	r = 0.707	$P < 0.100^S$
	Mean	Y = 1.1 + 1.26 X	r = 0.740	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.699 + 1.7 X	r = 0.742	$P < 0.100^S$
	R_2	Y = 2.6 + 1.1 X	r = 0.623	$P < 0.200^S$
	R_3	Y = 1.3 + 0.8 X	r = 0.600	$P < 0.200^S$
	Mean	Y = 1.53 + 1.2 X	r = 0.743	$P < 0.100^S$
Fruit weights	R_1	Y = 3.89 + 9.74 X	r = 0.748	$P < 0.100^S$
	R_2	Y = 8.95 + 6.35 X	r = 0.739	$P < 0.100^S$
	R_3	Y = 4.32 + 8.7 X	r = 0.748	$P < 0.100^S$
	Mean	Y = 5.72 + 8.27 X	r = 0.748	$P < 0.100^S$
Galls (No.)	R_1	Y = 97.5 – 33 X	r = -0.736	$P < 0.100^S$
	R_2	Y = 156.6 - 60.9 X	r = -0.648	$P < 0.200^S$
	R_3	Y = 238.2 - 94.8 X	r = -0.637	$P < 0.200^S$
	Mean	Y = 164.1 - 62.9 X	r = -0 662	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 21.8 - 6.2 X	r = -0.748	$P < 0.100^S$
	R_2	Y = 18.9 - 6.1 X	r = -0.740	$P < 0.100^S$
	R_3	Y = 25.3 - 8.7 X	r = -0.685	$P < 0.200^S$
	Mean	Y = 22 – 7 X	r = -0.729	$P < 0.100^S$

But apparently all the doses of Mocap had detrimental effect on nematode population, because the minimum shoot length was encountered in plants that were not treated by any nematicides ($P<0.10$) [Fig. 37, Table 7].

2. Effect on Shoot Weight

The weight of shoot of experimental plants exhibited maximum growth at 3% dosage in R_1 replicates, while minimum growth was recorded at 1% dosage in R_3 replicates, which showed slight decrease in shoot length over untreated control. Linear regression trends exhibited significant increase ($P < 0.20$ - $P < 0.10$) [Fig. 38, Table 7].

3. Effect on Root Length

The maximum growth of root length was recorded at 3% dosage in R_1 replicate, while minimum growth was observed at 1% dosage in R_3 replicates which was at par with untreated control ($P < 0.20$ - $P < 0.10$) [Fig. 38, Table 7].

4. Effect on Root Weight

The R_1 replicate of experimental plants exhibited highest growth at 3% dosage, while minimum

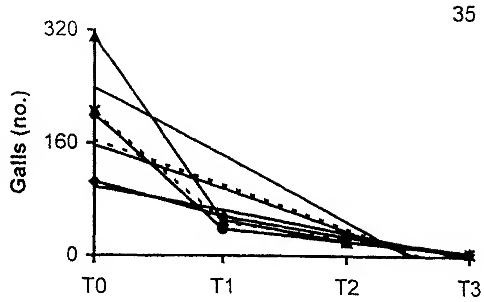
growth was recorded in R_2 replicates at 1 % dosage. There was slight decrease in root weight at 1% dosage over untreated control in R_3 replicates ($P < 0.20 - P < 0.10$) [Fig. 40, Table 7].

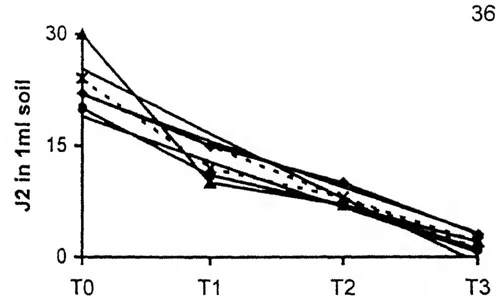
5. Effect on Number of Leaves

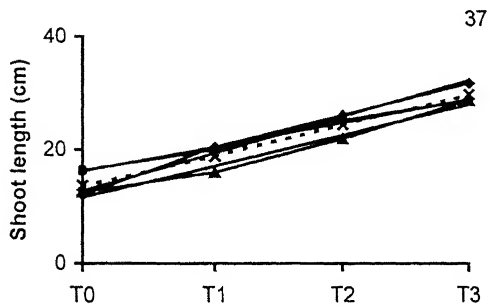
The number of leaves in experimental plants was after seed treatment by maximum 3% dosage in R_2 replicates. The efficacy of nematicide at 1% and 2% dosage in R_2 replicates were at par with each other. But a sudden decrease was recorded in the number of leaves in R_3 replicate at 3% dosage. The linear regression trend showed a non-significant growth pattern in R_3 ($P > 0.50$), while it was significant in R_1 and R_2 replicates ($P < 0.10$) [Fig. 41, Table 7].

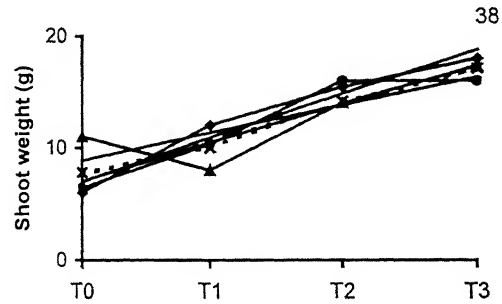
6. Effect on Number of Fruits

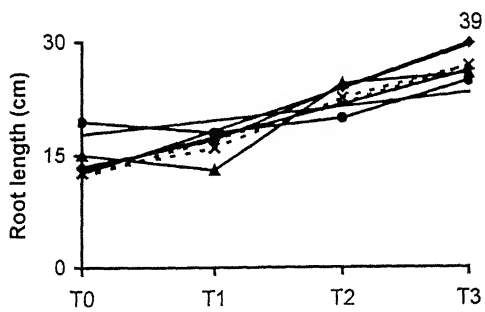
The maximum number of fruits were observed at 3% dosage in R_2 replicates, while minimum number of fruits were recorded at 1% dose in R_1 replicates. The R_2 replicates showed higher number of fruits at all the three

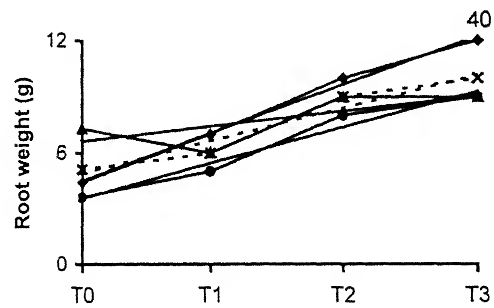

35
320
160
0
Galls (no.)
T0
T1
T2
T3

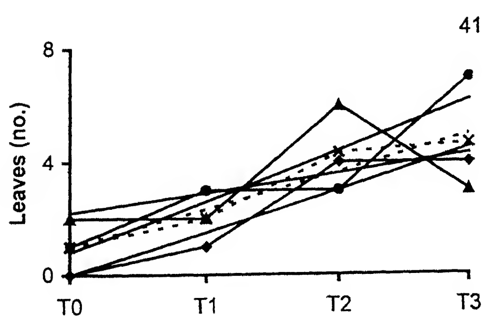

36
30
15
0
J2 in 1ml soil
T0
T1
T2
T3

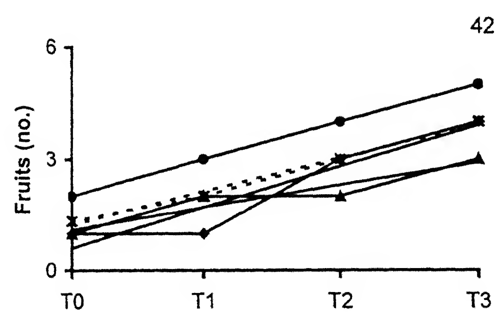

37
40
20
0
Shoot length (cm)
T0
T1
T2
T3


38
20
10
0
Shoot weight (g)
T0
T1
T2
T3


39
30
15
0
Root length (cm)
T0
T1
T2
T3


40
12
6
0
Root weight (g)
T0
T1
T2
T3


41
8
4
0
Leaves (no.)
T0
T1
T2
T3


42
6
3
0
Fruits (no.)
T0
T1
T2
T3

dosages of Mocap than the other two replicates ($P < 0.10$) [Fig. 42, Table 7].

7. Effect on Weight of Fruits

The weight of fruits was maximum at 3% dosage in R_1 replicates, but minimum at 1% dosage in R_3 replicates. Linear regression pattern showed that in all the replicates growth in the weight of fruits was better at the increase in dose of nematicides. ($P < 0.10$) [Fig. 43, Table 7].

8. Effect on Number of Galls

The number of galls in the root of ***A. esculentus*** exhibited significant reduction at 3% dosage on application of 3 dosages within R_1, R_2, R_3 replicates in potted plants. The lowest efficacy was of 1% dosage out of the three dosages. Interestingly, sudden declining effect of nematicides was apparent at 1% dosage on R_1, R_2 and substantial decline occurred in R_3, R_2 replicates. ($P < 0.20$ – $P < 0.10$) [Fig. 44, Table 7].

9. Effect on Number of J_2 In 1ml Soil

Table 7 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Mocap (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 12.78 + 6.58 X	r = 0.746	$P < 0.100^S$
	R_2	Y = 16.14 + 4.34 X	r = 0.747	$P < 0.100^S$
	R_3	Y = 11.55 + 5.55 X	r = 0.742	$P < 0.100^S$
	Mean	Y = 13.49 + 5.49 X	r = 0.749	$P < 0.100^S$
Shoot weight	R_1	Y = 6.94 + 3.94 X	r = 0.735	$P < 0.100^S$
	R_2	Y = 7 + 7.45 X	r = 0.711	$P < 0.100^S$
	R_3	Y = 8.84 + 2.49 X	r = 0.604	$P < 0.200^S$
	Mean	Y = 7.49 + 3.19 X	r = 0.746	$P < 0.100^S$
Root length	R_1	Y = 12.59 + 5.69 X	r = 0.744	$P < 0.100^S$
	R_2	Y = 10.78 + 4.88 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 12.96 + 4.46 X	r = 0.654	$P < 0.200^S$
	Mean	Y = 12.46 + 4.82 X	r = 0.721	$P < 0.100^S$
Root weight	R_1	Y = 4.480 + 2 58 X	r = 0.747	$P < 0.100^S$
	R_2	Y = 3.52 + 1.92 X	r = 0 736	$P < 0.100^S$
	R_3	Y = 6.61+ 0.81 X	r = 0.538	$P < 0.200^S$
	Mean	Y = 4.87 + 1.77 X	r = 0.730	$P < 0.100^S$
Leaves (No.)	R_1	Y = 0 + 1.5 X	r = 0.704	$P < 0.100^S$
	R_2	Y = 0.80 + 1 8 X	r = 0.692	$P < 0.100^S$
	R_3	Y = 2.2 + 0 7 X	r = 0.358	$P > 0.50^{NS}$
	Mean	Y = 1.0 + 1.33 X	r = 0.723	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.599 + 1 1 X	r = 0.710	$P < 0.100^S$
	R_2	Y = 2 + 1 X	r = 0.750	$P < 0.100^S$
	R_3	Y = 1.1 + 0.6 X	r = 0.711	$P < 0.100^S$
	Mean	Y = 1.23 + 0 901 X	r = 0.747	$P < 0.100^S$
Fruit weights	R_1	Y = 3 76 + 6 51 X	r = 0.747	$P < 0.100^S$
	R_2	Y = 7.63 + 4.53 X	r = 0.742	$P < 0.100^S$
	R_3	Y = 3.49 + 6.09 X	r = 0.746	$P < 0.100^S$
	Mean	Y = 4.95 + 5.71 X	r = 0.747	$P < 0.100^S$
Galls (No.)	R_1	Y = 94.1 - 30.4 X	r = -0.713	$P < 0.100^S$
	R_2	Y = 158.4 - 58.1 X	r = -0 645	$P < 0.200^S$
	R_3	Y = 235.3 - 91.2 X	r = -0.623	$P < 0.200^S$
	Mean	Y = 162.6 - 59.9 X	r = -0.648	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 21.3 - 6.2 X	r = -0.746	$P < 0.100^S$
	R_2	Y = 19.7 - 5.8 X	r = -0.746	$P < 0.100^S$
	R_3	Y = 24.5 – 8 X	r = -0.653	$P < 0.200^S$
	Mean	Y = 21.8 - 6.7 X	r = -0.724	$P < 0.100^S$

In the soil of potted plants the number of J_2 was highly reduced at 3% in R_2 replicates, while minimum reduction were observed at 1% dosage in R_2 replicates. There was a sharp declining effect of nematicides observed at 1 % dosage in R_3 replicate. ($P < 0.20$ - $P < 0.10$) [Fig. 45, Table 7].

D. Effect of Phorate

1. Effect on Shoot Length

No significant variations were found in the length of shoot after application of all the 3 dosages of Phorate within R_1 R_2 and R_3 replicates of ***A. esculentus***. Linear regression patterns showed statistically significant increase, the peak attained at 3% dosage, in R_3 replicates. But apparently all the dosages of Phorate had detrimental effect on nematode population because minimum shoot length was encountered in control plants that were not treated by any of the nematicides ($P < 0.20$ - $P < 0.10$) [Fig. 46, Table 8].

2. Effect on Shoot Weight

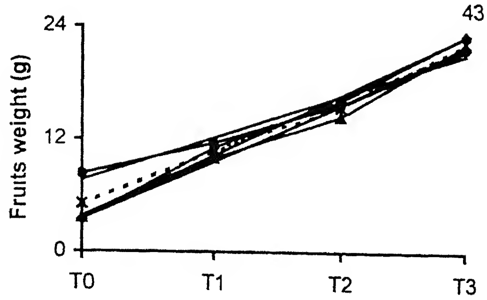
The quantum gain in the weight of shoot was negligible in R_3 replicates ($P > 0.50$) when different doses of 1-3% Phorate were applied on seeds of potted plants before experiment. The increasing effect of nematicides' application was recorded in R_2 replicates from 1 to 3% doses, and in R_1 replicates at 2% and 3% dosage ($P < 0.20 - P < 0.10$) (Fig. 47, Table 8).

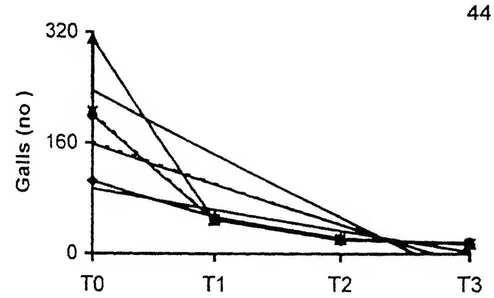
3. Effect on Root Length

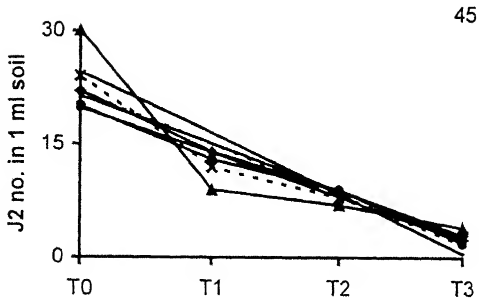
The change in root length was not substantial in R_3 replicate after seed treatment by Phorate. On the contrary, the consistently inclining influence on the length of the root was observed in R_1 and R_2 replicates of experimental plants whose seeds were treated by Phorate ($P < 0.20 - P < 0.10$) (Fig. 48, Table 8).

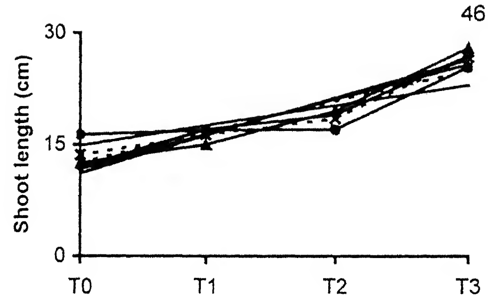
4. Effect on Root Weight

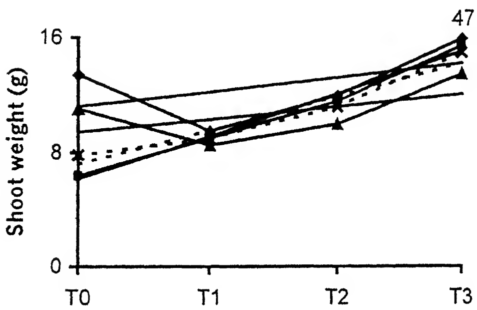
The linear regression patterns showed significantly enhanced influence of Phorate seed treatment in R_1 and R_2 replicates ($P < 0.20 - P < 0.10$) (Fig. 49, Table 8) while toxic influence of phorate could be established ($P > 0.50$) in R_3 replicates where reduction in


43
Fruits weight (g)
24
12
0
T0
T1
T2
T3


44
Galls (no.)
320
160
0
T0
T1
T2
T3


45
J2 no. in 1 ml soil
30
15
0
T0
T1
T2
T3


46
Shoot length (cm)
30
15
0
T0
T1
T2
T3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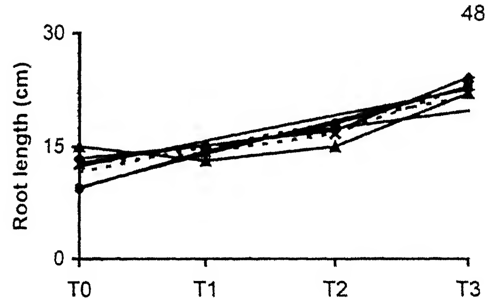
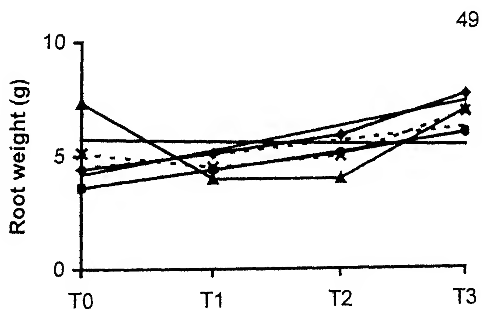
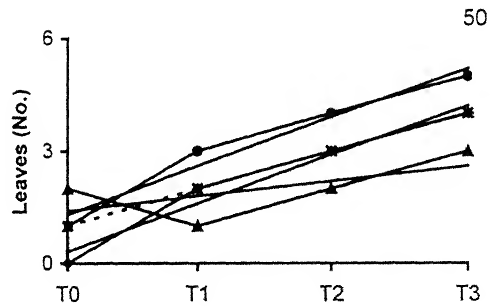
Shoot weight (g)
16
8
0
T0
T1
T2
T3


48
Root length (cm)
30
15
0
T0
T1
T2
T3


49
Root weight (g)
10
5
0
T0
T1
T2
T3


50
Leaves (No.)
6
3
0
T0
T1
T2
T3

weight of root was recorded than control at all 1-3% doses of nematicides.

5. Effect on No. of Leaves

The linear regression patterns showed significantly enhanced influence of Phorate seed treatment in R_1 and R_2 replicates ($P < 0.20$ - $P < 0.10$) (Fig. 50, Table 8) while toxic influence of Phorate could be established ($P > 0.50$) in R_3 replicates where reduction in number of leaves was recorded than control at all 1-3% doses of the nematicides.

6. Effect on No. of Fruits

The better production of fruits could be correlated more significantly ($P < 0.20$ - $P < 0.10$) with 2% dosage of Phorate than the lower (1%) or higher (3%) concentration in R_3 replicates so much so that the quantity of fruit production declined in R_2 replicate resulting into the yield down to the level of controls. [Fig. 51, Table 8].

7. Effect on Weight of Fruits

The maximum weight of fruits was observed at 3% concentration in R_1 replicate, while minimum at 1 %

dosage in R_3 replicate. The efficacy of 2% and 3% doses were uniform in R_3 replicates. Linear regression patterns were statistically significant ($P < 0.10$). A critical analysis of scatterplots would reveal efficacious results at 2% than at 1% or 3% doses of nematicides, while increase in fruit weight was substantial between 1% to 2% dosage effect of seed treatment by Phorate. The increase, further, in R_1 replicate was not marked, in R_2 replicates stabilized, but in R_3 even declined slightly at 3% dosage. [Fig. 52, Table 8].

8. Effect on Number of Root-Knot Galls and J_2 In 1ml Soil

The statistically significant decline in the number of galls as well as J_2 larvae in soil around ***A. esculentus*** was the main feature of the study while seeds were treated with Phorate. The only differentiating feature was that the decline in the number of galls (Fig. 35) as well as no. of J_2 larvae (Fig. 36) was steady in R_1 replicates but it was pretty sharp when seed treatment by Phorate was applied to R_2 and R_3 replicates [Figs. 53, 54, Table 8] ($P < 0.10$).

Table 8 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Phorate (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 11.7 + 4.7 X	r = 0.729	$P < 0.100^S$
	R_2	Y = 14.79 + 2.74 X	r = 0.610	$P < 0.200^S$
	R_3	Y = 11.1 + 5.1 X	r = 0.724	$P < 0.100^S$
	Mean	Y = 12.53 + 4.77 X	r = 0.710	$P < 0.100^S$
Shoot weight	R_1	Y = 6 + 3.25 X	r = 0.747	$P < 0.100^S$
	R_2	Y = 6.14 + 2.99 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 9.39 + 0.9 X	r = 0.414	$P > 0.50^{NS}$
	Mean	Y = 7.18 + 2.38 X	r = 0.728	$P < 0.100^S$
Root length	R_1	Y = 12.31 + 3.41 X	r = 0.702	$P < 0.100^S$
	R_2	Y = 9 55 + 4.41 X	r = 0.748	$P < 0.100^S$
	R_3	Y = 12.84 + 2.29 X	r = 0.565	$P < 0.200^S$
	Mean	Y = 11.57 + 3.37 X	r = 0.713	$P < 0.100^S$
Root weight	R_1	Y = 4 17 + 1.07 X	r = 0.728	$P < 0.100^S$
	R_2	Y = 3.59 + 0 79 X	r = 0 749	$P < 0.100^S$
	R_3	Y = 5.71 - 0.009 X	r = 0.478	$P > 0.50^{NS}$
	Mean	Y = 4.49 + 0.590 X	r = 0.544	$P < 0.200^S$
Leaves (No.)	R_1	Y = 0.30 + 1.3 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 1 3 + 1 3 X	r = 0.737	$P < 0.100^S$
	R_3	Y = 1 4 + 0.4 X	r = 0.474	$P > 0.50^{NS}$
	Mean	Y = 1 + 1 X	r = 0.750	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.700 + 0.7 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 2.1 + 0.1 X	r = 0.193	$P > 0.50^{NS}$
	R_3	Y = 1.5 + 1 X	r = 0.684	$P < 0\ 100^S$
	Mean	Y = 1 431 + 0.601 X	r = 0.711	$P < 0.100^S$
Fruit weights	R_1	Y = 4 96 + 4.71 X	r = 0.716	$P < 0.100^S$
	R_2	Y = 8.71 + 2.66 X	r = 0.733	$P < 0.100^S$
	R_3	Y = 4.41 + 3.82 X	r = 0.691	$P < 0.100^S$
	Mean	Y = 6.03 + 3.73 X	r = 0.716	$P < 0.100^S$
Galls (No.)	R_1	Y = 107.1 - 29.9 X	r = -0.746	$P < 0.100^S$
	R_2	Y = 173 - 59.5 X	r = -0.702	$P < 0.100^S$
	R_3	Y = 245 8 - 91.2 X	r = -0.649	$P < 0.200^S$
	Mean	Y = 175.3 - 60.2 X	r = -0.695	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 21.9 - 5.6 X	r = -0.749	$P < 0.100^S$
	R_2	Y = 19.3 - 5.2 X	r = -0.745	$P < 0.100^S$
	R_3	Y = 27.8 - 8.7 X	r = -0.734	$P < 0.200^S$
	Mean	Y = 23 - 6.5 X	r = -0.743	$P < 0.100^S$

E. Effect of Aldicarb

1. Effect on Shoot Length

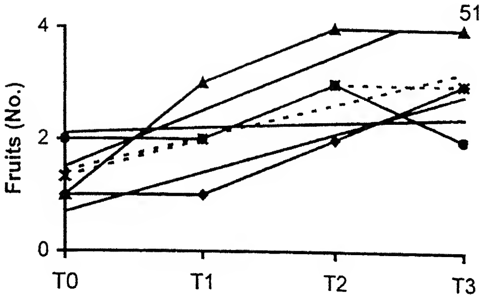
The length of shoot in the experiment dealing with application of three dosages of Aldicarb in R_1, R_2 and R_3 replicates of ***A. esculentus*** exhibited significant increase with peak being attained at 3% dosage. Apparently, all the dosages of Aldicarb had detrimental effect on nematode populations, because the minimum shoot length was observed in plants that were not treated by any of the nematicides ($P < 0.10$) [Fig. 55, Table 9].

2. Effect on Shoot and Root Weight

The shoot weight (Fig. 56) and root weight (Fig. 58) of the experimental plants were at peak at 3% dosage in R_1 and R_2 replicates, while minimum at 1% dosage in all the replicates ($P < 0.10$). The distinguishing feature of the experiment was that the nematicide exhibited no influence in R_3 replicate when seed treatment with 1% and 2% dosage were given, but 3% dosage showed marked impact and the weight immediately rose to the level at par found in R_1 and R_2 replicates [Figs. 56, 58, Table 9].

3. Effect on Root Length

51



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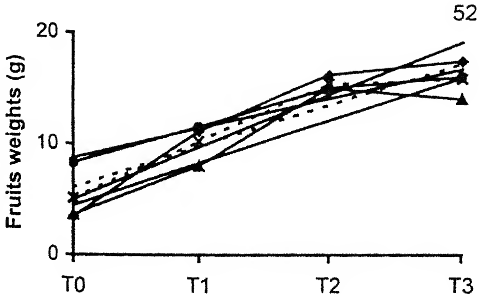

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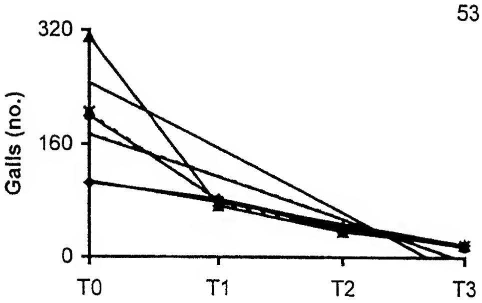

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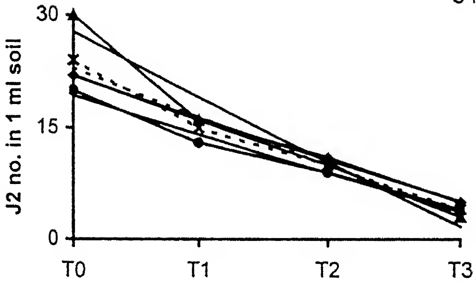

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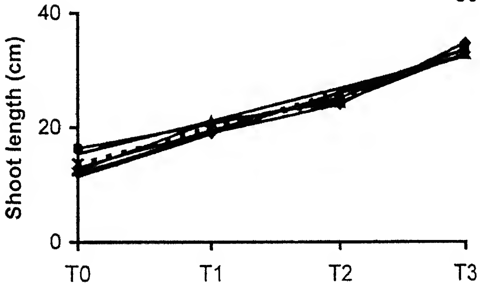

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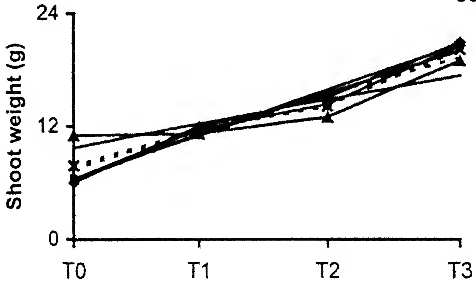

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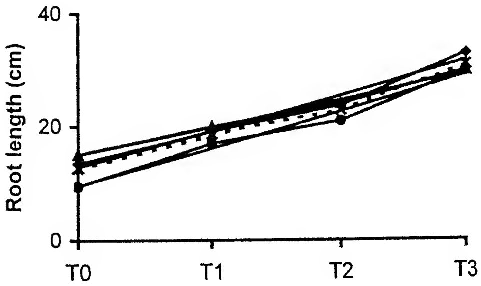
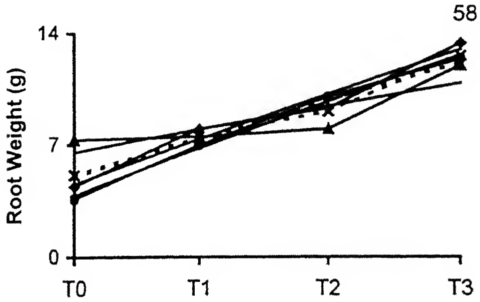


58



All the dosage of Aldicarb revealed statistically significant correlation with the length of root in R_1, R_2 and R_3 replicates of experimental plants, peak being attained at 3% dosage in R_1 replicates. The minimum growth was observed in the plants, that were not treated by nematicides ($P < 0.10$) [Fig. 57, Table 9].

4. Effect on Number of Leaves

Linear regression trends showed that all the three dosage of Aldicarb was highly effective to increase the number of leaves, peak being attained at 3% dosage in R_3 replicates. The minimum number of leaves were recorded in untreated plants ($P < 0.10$) [Fig. 59, Table 9].

5. Effect on Number of Fruits

The 3% dosage of Aldicarb exhibited highest number of fruits in R_3 replicates while at 1 % dosage minimum number of fruits occurred in R_1 replicates. The efficacy of 1% and 2% dosages were at par in R_2 and R_3 replicates. However, the yield of fruits remained steady thereafter in R_1 replicate, but it increased markedly to reach peak in R_2 and R_3 replicates ($P < 0.10$) [Fig. 60, Table 9].

Table 9 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Aldicarb (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 11.41 + 7.41 X	r = 0.740	$P < 0.100^{S}$
	R_2	Y = 15.37 + 5.770 X	r = 0.737	$P < 0.100^{S}$
	R_3	Y = 13 + 6.5 X	r = 0.741	$P < 0.100^{S}$
	Mean	Y = 13.26 + 6.56 X	r = 0.742	$P < 0.100^{S}$
Shoot weight	R_1	Y = 6.3 + 4.8 X	r = 0.744	$P < 0.100^{S}$
	R_2	Y = 6.4 + 4.53 X	r = 0.742	$P < 0.100^{S}$
	R_3	Y = 9.68 + 2.58 X	r = 0.667	$P < 0.200^{S}$
	Mean	Y = 7.47 + 3.9 X	r = 0.738	$P < 0.100^{S}$
Root length	R_1	Y = 12.79 + 6.34 X	r = 0.740	$P < 0.100^{S}$
	R_2	Y = 9.47 + 6.58 X	r = 0.742	$P < 0.100^{S}$
	R_3	Y = 14.9 + 4.9 X	r = 0.747	$P < 0.200^{S}$
	Mean	Y = 12.39 + 5.94 X	r = 0.744	$P < 0\ 100^{S}$
Root weight	R_1	Y = 4.53 + 2.83 X	r = 0.737	$P < 0.100^{S}$
	R_2	Y = 3.84 + 2.94 X	r = 0.747	$P < 0\ 100^{S}$
	R_3	Y = 6.51 + 1.46 X	r = 0.636	$P < 0.200^{S}$
	Mean	Y = 4.96 + 2.41 X	r = 0.741	$P < 0.100^{S}$
Leaves (No.)	R_1	Y = 0.599 + 1.6 X	r = 0.717	$P < 0.100^{S}$
	R_2	Y = 1.6 + 1.6 X	r = 0.717	$P < 0\ 100^{S}$
	R_3	Y = 2.6 + 1.6 X	r = 0.717	$P > 0\ 100^{S}$
	Mean	Y = 1.6 + 1.6 X	r = 0.717	$P < 0.100^{S}$
Fruits (No.)	R_1	Y = 1.3 + 1.8 X	r = 0.711	$P < 0.100^{S}$
	R_2	Y = 2.5 + 1.5 X	r = 0.704	$P < 0\ 100^{S}$
	R_3	Y = 1.1 + 2.1 X	r = 0.707	$P < 0.100^{S}$
	Mean	Y = 1.63 + 1.80 X	r = 0.739	$P < 0\ 100^{S}$
Fruit weights	R_1	Y = 6.32 + 11.37 X	r = 0.726	$P < 0.100^{S}$
	R_2	Y = 8.23 + 9.63 X	r = 0.726	$P < 0.100^{S}$
	R_3	Y = 8.51 + 10.02 X	r = 0.696	$P < 0.100^{S}$
	Mean	Y = 7.69 + 10.34 X	r = 0.729	$P < 0.100^{S}$
Galls (No.)	R_1	Y = 94.5 - 33.5 X	r = -0.725	$P < 0.100^{S}$
	R_2	Y = 159.4 - 61.1 X	r = -0.659	$P < 0.200^{S}$
	R_3	Y = 236.9 - 94.1 X	r = -0.633	$P < 0.200^{S}$
	Mean	Y = 163.6 - 62.9 X	r = -0.660	$P < 0.200^{S}$
J2 in 1ml soil	R_1	Y = 19.9 - 6.6 X	r = -0.723	$P < 0.100^{S}$
	R_2	Y = 19.6 - 6.4 X	r = -0.747	$P < 0.100^{S}$
	R_3	Y = 25.9 - 8.60 X	r = -0.698	$P < 0.100^{S}$
	Mean	Y = 21.8 - 7.2 X	r = -0.726	$P < 0.100^{S}$

6. Effect on Weight of Fruits

The increase in weight of fruits was marked in all the 3 replicates when 1 % dosage of Aldicarb was applied to control plants. It steadied a bit thereafter, and in plants with 2% dosages treated seeds, it rose again to attain peak growth in weight of fruits at 3% dosage in all the replicates ($P > 0.10$) [Fig. 61, Table 9].

7. Effect on Number of Galls and J_2 Stage Larvae

The effect of 1% dosage of nematicide in seed treatment was very well marked exhibiting sharp decline in number of galls as well as those of J_2 juveniles. The decline was steady thereafter at 2% and 3% dosage ($P < 0.10$) [Figs. 62, 63, Table 9].

F. Effect of Acephate

1. Effect on Shoot Length

The length of shoot of experimental plants by the application of the 3 dosages of Acephate revealed that the maximum growth occurred at 3% dose in R_1 replicates and 1% and 2% concentrations of Acephate did not show any effect on the length of shoot ($P < 0.20$ - $P < 0.10$) [Fig. 64, Table 10].

2. Effect on Shoot Weight

The maximum growth in weight of shoot of experimental plants was exhibited by R_3 replicates at 3% dose, but the same replicate showed slight decrease in shoot weight at 1% dose when compared with untreated plants. The minimum growth was observed at 1% dose in R_2 replicates ($P < 0.20 - P < 0.10$) [Fig. 65, Table 10].

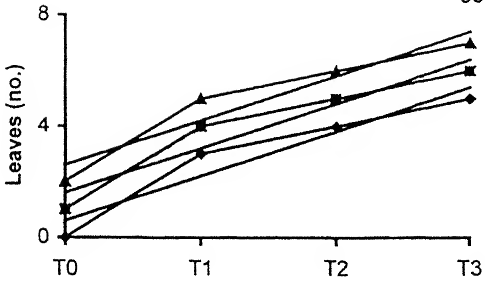
3. Effect on Root Length

All the replicates showed no wide variations in their length of their root after treatment with different dosages of nematicides. With no effect of 1% and 2% concentrations of Acephate, 3% dose exhibited maximum growth in root length in all the replicates. The growth pattern, however, was significant statistically ($P < 0.20 - P < 0.10$) [Fig. 66, Table 10].

4. Effect on Root Weight

The weight of root was maximum at 3% dosage in R_1 replicates and minimum at 1% dosage in R_2 replicates. R_3 replicates exhibited decreased root weight at 1% and 2% dosage in comparison to untreated plant.

59



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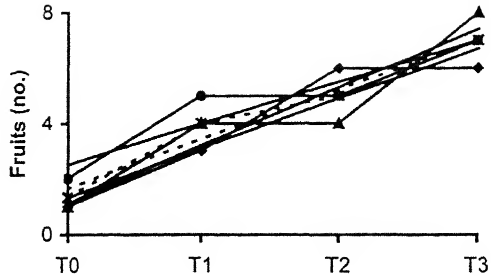

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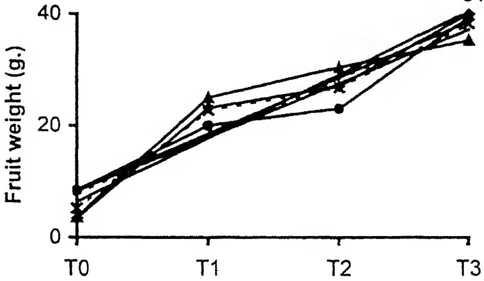

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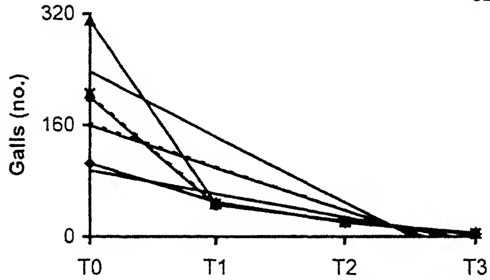

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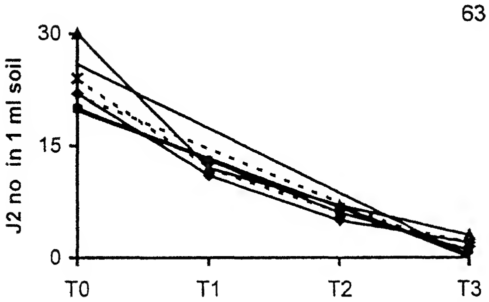

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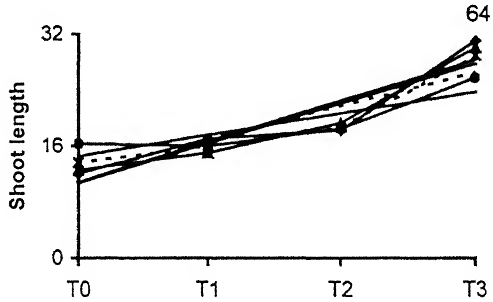

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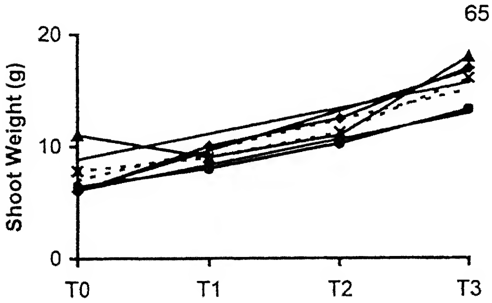

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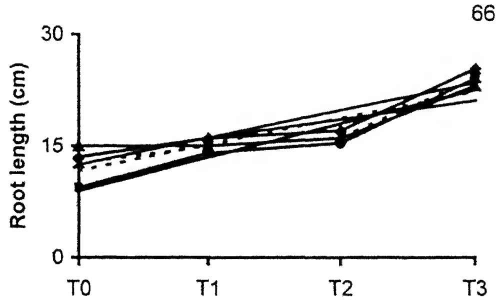


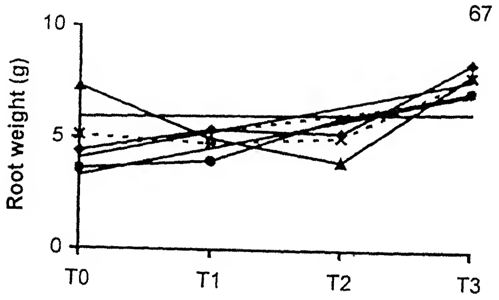
The changes in root weight could not be correlated with seed treatments ($P > 0.50$) with 1-3% concentration of Acephate in R_3 replicates. The linear regression patterns were statistically significant in R_1 and R_2 replicates ($P < 0.20$ - $P < 0.10$) [Fig. 67, Table 10].

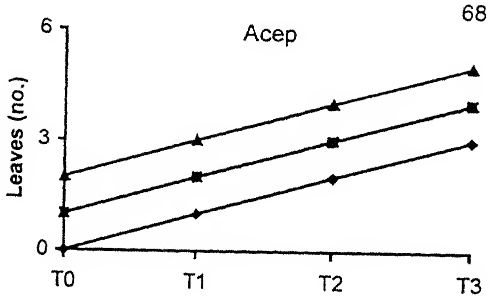
5. Effect on Number of Leaves

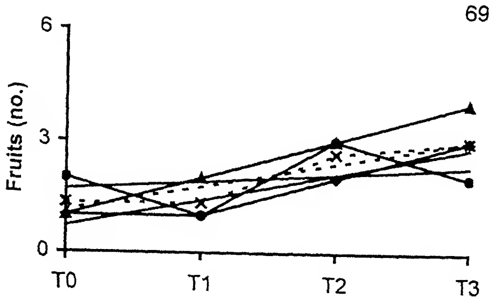
Linear regression patterns were similar in all the replicates which exhibited statistically significant increase in the number of leaves with increasing dosage of nematicides. The highest number of leaves was recorded at 3% dosages in R_3 replicates and minimum number occurred at 1% dose in R_1 replicates. The efficacy of all the dosages were found statistically significant, because the lowest number of leaves were found in the plants which were not treated by nematicides ($P < 0.10$) [Fig. 68, Table 10].

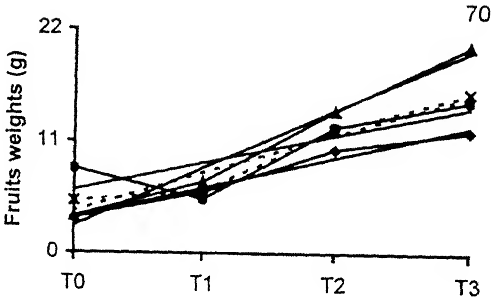
6. Effect on Number of Fruits

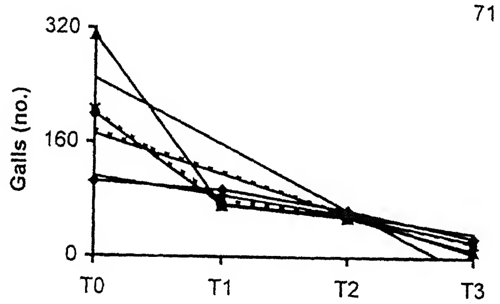
The maximum number of fruits were recorded at 3% dose in R_3 replicates, while least effective dosage was 1% in R2 replicate. The R_2 replicate exhibited decrease in the number of fruits at 1% dosage over untreated plant as


67
10
5
0
Root weight (g)
T0
T1
T2
T3


68
Acep
6
3
0
Leaves (no.)
T0
T1
T2
T3


69
6
3
0
Fruits (no.)
T0
T1
T2
T3


70
22
11
0
Fruits weights (g)
T0
T1
T2
T3


71
320
160
0
Galls (no.)
T0
T1
T2
T3

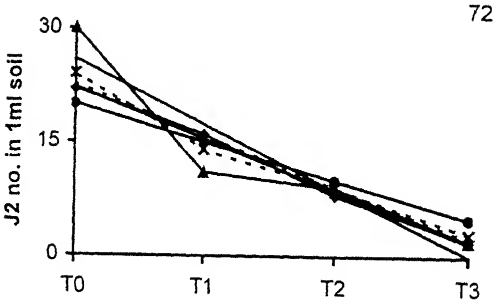

72
30
15
0
J2 no. in 1ml soil
T0
T1
T2
T3

Table 10 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after seed treatment by Acephate (1%, 2%, 3% w/w) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 10.82 + 5.82 X	r = 0.696	$P < 0.200^S$
	R_2	Y = 14.51 + 3.06 X	r = 0.654	$P < 0.200^S$
	R_3	Y = 10.67 + 5.67 X	r = 0.710	$P < 0.100^S$
	Mean	Y = 12 + 4.85 X	r = 0.697	$P < 0.200^S$
Shoot weight	R_1	Y = 6.05 + 3.55 X	r = 0.746	$P < 0.100^S$
	R_2	Y = 6.05 + 2.295 X	r = 0.742	$P < 0.100^S$
	R_3	Y = 8.8 + 2.3 X	r = 0.564	$P < 0.200^S$
	Mean	Y = 6.96 + 2.7 X	r = 0.717	$P < 0.100^S$
Root length	R_1	Y = 12.42 + 3.67 X	r = 0.690	$P < 0.200^S$
	R_2	Y = 8.91 + 4.51 X	r = 0.715	$P < 0.100^S$
	R_3	Y = 13.5 + 2.5 X	r = 0.626	$P < 0.200^S$
	Mean	Y = 11.61 + 3.56 X	r = 0.691	$P < 0.200^S$
Root weight	R_1	Y = 4.07 + 1.22 X	r = 0.659	$P < 0.200^S$
	R_2	Y = 3.28 + 1 28 X	r = 0.730	$P < 0.100^S$
	R_3	Y = 5.91 + 0.109 X	r = 0.564	$P > 0.50^{NS}$
	Mean	Y = 4.42 + 0.87 X	r = 0.578	$P < 0.200^S$
Leaves (No.)	R_1	Y = 0 + 1 X	r = 0.750	$P < 0.100^S$
	R_2	Y = 1 + 1 X	r = 0.750	$P < 0.100^S$
	R_3	Y = 2 + 1 X	r = 0.750	$P > 0.100^S$
	Mean	Y = 1 + 1 X	r = 0.750	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.70 + 0.7 X	r = 0 707	$P < 0.100^S$
	R_2	Y = 1.7 + 0.2 X	r = 0.237	$P > 0.50^{NS}$
	R_3	Y = 1 + 1 X	r = 0 750	$P < 0.100^S$
	Mean	Y = 1.12 + 0.63 X	r = 0.699	$P < 0.100^S$
Fruit weights	R_1	Y = 3.4 + 3 X	r = 0.742	$P < 0.100^S$
	R_2	Y = 6.17 + 2.72 X	r = 0.612	$P < 0.100^S$
	R_3	Y = 2.64 + 5.74 X	r = 0.742	$P < 0.100^S$
	Mean	Y = 4.07 + 3.82 X	r = 0.727	$P < 0.100^S$
Galls (No.)	R_1	Y = 112.1 - 25.9 X	r = -0.730	$P < 0.100^S$
	R_2	Y = 171 - 55 X	r = -0.687	$P < 0.100^S$
	R_3	Y = 249.4 - 91.6 X	r = -0.658	$P < 0.200^S$
	Mean	Y = 177.5 - 57.5 X	r = -0.697	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 22 2 - 6.8 X	r = -0.748	$P < 0.100^S$
	R_2	Y = 20 – 5 X	r = -0.750	$P < 0.100^S$
	R_3	Y = 25.9 - 8.6 X	r = -0.695	$P < 0.100^S$
	Mean	Y = 22.7 - 6.8 X	r = -0.740	$P < 0.100^S$

well as decreased growth rate at 3% dosage in comparison to 2% dosage. Linear regression trends showed significant increase in R_1 and R_3 ($P < 0.10$), but non-significant in R_2 ($P > 0.50$) [Fig. 69, Table 10].

7. Effect on Weight of Fruits

Like the number of fruits, the weight of fruits also exhibited highest growth at 3% dosage in R_3 replicates and lowest growth at 1% dosage in R_2 replicates. But the linear regression pattern showed statistically significant increase in the weight of fruits in all the replicates ($P < 0.10$) [Fig. 70, Table 10].

8. Effect on Number of Galls and J_2 Stage Larvae

The number of galls in the roots of experimental plants were highly reduced at 3% dosages in R_3 replicates as those of J_2 larvae in soil around ***A. esculentus***. The sudden declining effect of nematicides appeared in R_2 and R_3 replicates at 1% dosages which showed maximum reduction over untreated plants ($P<0.10$) [Figs. 71,72, Table 10].

Comparison of different nematicides used as seed treatment against *M. incognita* on *A. esculentus*

ANOVA was performed on the data obtained from the application of nematicides on seeds of ***A. esculentus*** in various experiments. The comparison of different dosages of all the nematicides on different growth parameters were based on the value of three replicates of the plants. Further, the comparative trends emerging from ANOVA were substantiated by the evaluation in terms of growth parameters. The tool of Critical Difference (CD) was employed. The mean value of three replicates have been mentioned in parentheses.

1. Effect on Shoot Length

The statistical evaluation of data on shoot length revealed high degree of significance by ANOVA ($F_{2,18}$ = 18.025). The highest growth was observed at 3% dose of different nematicides in the following sequence:- Fensulphothion (34.1 cm) > Aldicarb (34.00 cm) > Carbofuran (33.70 cm) > Mocap (30.00 cm) > Acephate (28.90 cm) , Phorate (26.80 cm).

The least effective dosages were 1% Acephate (16.00 cm) > 1% Phorate (16.30 cm) over untreated control

(13.60 cm) on the basis of $CD_{5\%}$ = 4.30 $CD_{1\%}$ = 5.79. The results of ANOVA are as follows: -

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	2164.92	920.27	180.25	1.99
Replication	2	19.20	9.60		

SE = 2.109 $CD_{5\%}$ = 4.30 $CD_{1\%}$=5.79

2. Effect on Shoot Weight

The shoot weight exhibited high degree of significance by ANOVA ($F_{2,18}$ = 7.86). 3% dosages of different nematicides were highly effective. The order of their effectiveness was-

Aldicarb (20.20 gm) > Fensulphothion (19.80 gm) > Carbofuran (19.30 gm) > Acephate (17.10 gm) > Phorate (16.10 gm).

The nematicides that showed no significant effect on growth of the shoot weight were 1% Phorate and 1% Acephate (9.00 g) over untreated control (7.80 g). $CD_{5\%}$=3.82 $CD_{1\%}$ = 5.15.

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	746.39	41.46	7.861	1.99
Replication	2	3.65	1.82		

SE = 1.875 $CD_{5\%}$ = 3.82 $CD_{1\%}$=5.15

3. Effect on Root Length

The statistical analysis on the data of root length on the basis of ANOVA ($F_{2,18}$ = 19.35) showed that the growth was superior and significant at 3% dosages. The order of their superiority were-

Fensulphothion (31.35 cm) < Aldicarb and Carbofuran (31.00 cm) < Mocap (27.00 cm) < Acephate (24.10 cm) < Phorate (23.00 cm).

The least effective dosages were 1% Phorate (14.10 cm) < 1% Acephate (15.00 cm) over untreated control (12.60 cm). The results of ANOVA follow: -

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	1817.17	100.95	19.35	1.99
Replication	2	99.63	49.81		

SE = 1.864 $CD_{5\%}$ = 5.12 $CD_{1\%}$=1.864

4. Effect on Root Weight

The statistical analysis of data on root weight exhibited high degree of significance by ANOVA ($F_{2,18}$ = 10.847). The maximum growth was recorded at 2% and 3% dosages of seed treatment by different nematicides in the following sequence-

3% Fensulphothion (12.70 g) > 3% Aldicarb (12.60 g) > 3% Carbofuran (12.10 g) > 3% Mocap (10.00 g) > 2% Fensulphothion (9.24 g) > 2% Aldicarb (9.10 g) > 2% Mocap (9.00 g) > 3% Acephate (7.90 g) > 3% Phorate (6.90 g).

All the nematicides at their 1% dosage were least effective. The efficacy of 1% phorate (4.50 g) and 1% Acephate (4.80 g) were non-significant when compared with untreated control (5.10 g) on the basis of $CD_{5\%}$ = 2.29 and $CD_{1\%}$ (3.09).

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	369.99	20.55	10.84	1.99
Replication	2	13.75	6.87		

SE = 1.123 $CD_{5\%}$ = 2.29 $CD_{1\%}$ = 3.09

5. Effect on the Number of Leaves

The data revealed that the highest concentration i.e. 3% dosages exhibited maximum number of leaves ($F_{2,18}$ = 4.83). The order of effectiveness of different dosages of nematicides was-

3% Aldicarb (6.00) > 3% Fensulphothion and 2% Aldicarb (5.00) > 3% Carbofuran and Mocap (4.66) > 2% Mocap (4.33).

The least effective dosages were 1% of all the nematicides (2.00) except, 1% Aldicarb (4.00) over untreated control (1.00) ($CD_{5\%}$= 1.76 and $CD_{1\%}$= 2.37). So 1% dosages were statistically non-significant and non - effective to result into an increase in the number of leaves. The results of ANOVA are as follows: -

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	97.54	5.41	4.83	1.99
Replication	2	8.31	4.15		

SE = 0.864 $CD_{5\%}$ = 1.76 $CD_{1\%}$ = 2.37

6. Effect on Number of Fruits

The data on number of fruits exhibited that 2% and 3% dosages of some nematicides were highly effective ($F_{2,18}$ = 4.59). The order of effectiveness was-

3% Aldicarb (7.00) > 3% Fensulphothion (5.33) > 3% Carbofuran and 2% Aldicarb (5.00).

The nematicides at 1% dosages were non-significant and non effective to increase the number of fruits. Non-effective nematicides were 1% Acephate (1.33) 1% phorate and Mocap (2.00) over untreated control (1.33) on the basis of $CD_{5\%}$ = 1.93 $CD_{1\%}$ = 2.61. The results of ANOVA follow:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	111.89	6.21	4.59	1.99
Replication	2	3.26	1.63		

SE = 0.950 $CD_{5\%}$ = 1.93 $CD_{1\%}$ = 2.61

7. Effect on Weight of Fruits

The data of weight of fruits indicated that 2% dosage of some nematicides and 3% dosages of all the nematicides exhibited significant increase in growth ($F_{2,18}$ = 14.58). The sequence of effectiveness was-

3% Aldicarb (38.20 g) > 2% Aldicarb (26.80 g) > 3% Carbofuran (30.30 g) > 3% Fensulphothion (26.56 g).

The least effective nematicides were 1% Phorate (6.10 g) < 2% Phorate (10.20 g) over untreated control

(5.10 g) on the basis of $CD_{5\%}$ = 6.40 $CD_{1\%}$ = 8.62. Aldicarb and Carbofuran were highly effective at all dosages. The results of ANOVA follow:-

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	3876.49	215.36	14.58	1.99
Replication	2	77.45	38.72		

SE = 3.13 $CD_{5\%}$ = 6.40 $CD_{1\%}$ = 8.62

8. Effect on Number of Galls

Statistical analysis on the number of root-knot galls indicated that all the treatments were significantly superior to untreated control ($CD_{5\%}$ = 40.96 $CD_{1\%}$ = 55.22). Among the treatments applied, 3% Fensulphothion showed least number of galls (4.00). Its efficacy was at par with Carbofuran 3% dosage and Aldicarb 3% dosage. It was followed by Mocap 3% dosage (20.00), 3% Acephate and 2% Fensulphothion (20.00), the effect of whom between themselves was at par. Likewise the effect of 2% Aldicarb (21.00) and 2% dosage Mocap (21.00) were also at par with each other. Acephate and Phorate at 1% dosage were least effective in their influence on reduction of number of galls. But all the nematicides were

significantly superior over untreated control (205.00). The order of their effectiveness was-

3% Fensulphothion > 3% Carbofuran > 3% Aldicarb ($F_{2,18}$ = 14.58).

The results of ANOVA are as under:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	113119.6	6284.42	10.39	1.99
Replication	2	21774.11	604.83		

SE = 20.08 $CD_{5\%}$ = 40.96 $CD_{1\%}$ = 55.22

9. Number of J_2 in 1ml Soil

All the treatments significantly reduced the number of J_2 in soil around ***A. esculentus***. The least number of J_2 in soil were recorded at highest concentration i.e. 3% dosage of Fensulphothion, Carbofuran and Aldicarb (2.00). It was followed by the effect of 3% dosage of Mocap and Acephate (3.00), which themselves were at par amongst each other. It was followed by 3% dosage of Phorate (4.00), 2% Aldicarb

(6.00), 2% Fensulphothion (6.66), 2% Carbofuran (8.00) and 2% Mocap (8.33). Phorate at 1% dosage (15.00) and Acephate at 1% (14.00) were found to be least effective in the reduction of number of J_2 in 1ml soil. But all the treatments were statistically significant and superior over untreated control (24.00) on the basis of $CD_{5\%}$ = 4.25) and $CD_{1\%}$ = 5.73 ($F_{2,\ 18}$ = 14.81). The results of ANOVA follow:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	1742.98	96.83	14.81	1.99
Replication	2	0.105	0.052		

SE = 2.08 $CD_{5\%}$ = 4.25 $CD_{1\%}$ = 5.73

Effect Of Nematcides As Pre-Inoculation Soil Treatment One Day Before Sowing Against *M. incognita* On *A. esculentus*

In this experiment all the six nematicides were used as pre-inoculation soil treatment one day before sowing of the seeds of ***A. esculantus***, in three different dosages 1, 2 and 4Kg a. i./ha. The effect of different

nematicides is described separately on different growth parameters of the experimental plants.

A. Effect of Fensulphothion

1. Effect on Shoot Length

The three different dosages i.e. 1, 2 and 4Kg a. i./ha Fensulphothion were used as soil treatment one day before sowing of the seeds of ***A. esculentus,*** and wide variation were observed with maximum growth at 4Kg a.i./ha in R_3 and R_1 replicates. The minimum growth was recorded at 1Kg a.i./ha in R_3 replicates. All the replicates exhibited similar growth pattern at 4 Kg a. i. /ha. ($P < 0.100$) [Fig. 73, Table 11]. The effect of the dosages was statistically significant because minimum shoot length were observed in plants that were not treated by any of the nematicides.

2. Effect on Shoot Weight

There were wide variations observed in the shoot weight of the experimental plants at different doses, with maximum growth at 4 Kg a. i. /ha. in R_2 replicates and minimum growth recorded at 1Kg a.i./ha in R_3 replicates. ($P < 0.100$) [Fig. 74, Table 11].

3. Effect on Root Length

The growth of the length of root revealed that 4Kg a.i./ha dose was significantly more effective in R_1 replicates than the other two dosages. The minimum growth was achieved in R_3 replicates at 1Kg a.i./ha ($P < 0.100$) [Fig. 75, Table 11].

4. Effect on Root Weight

The pattern of growth was similar in R_1 and R_2 replicates but maximum growth of root weight was achieved at 4 Kg a.i./ha in R_3 replicates, and minimum growth occurred at 1Kg a.i./ha in R_3 replicates ($P < 0.20 - P < 0.10$) [Fig. 76, Table 11].

5. Effect on Number of Leaves

The maximum number of leaves were observed in plants whose soil was treated with Fensulphothion @ 4Kg a. i./ha by R_2 replicates and minimum numbers were recorded in R_1 replicate at 1 Kg a. i./ha. There was significant increase in the number of leaves in all the replicates ($P < 0.10$) [Fig. 77, Table 11].

6. Effect on Number and Weight of Fruits

The quantum gain in number and weight of fruits was negligible in R_2 and R_3 replicates when 1Kg a.i./ha. dosages of Fensulphothion were applied in soil one day before sowing of seeds of **A. esculentus**. R_1 replicates showed substantial increase in the number and weight of fruits at 1Kg a.i./ha dosage. But thereafter sharp increase in the Number and weight of fruits occurred in all the replicates, with peak attained at 4 Kg a.i./ha ($P < 0.20 - P < 0.10$) [Fig. 78, 79, Table 11].

7. Effect on Number of Galls

The number of root-knot galls in the experimental plants were highly reduced at 4Kg a.i./ha in all the replicates while minimum reduction was recorded at 1Kg a.i./ha in R_3 replicates. Sudden decline in the number of galls was observed at 1Kg a. i. /ha dosage in R_1 and R_2 replicates. This gives an indication that the 1 Kg a./ i. /ha dosage of soil treatment could be effective to reduce the number of galls [Fig. 80, Table 11].

8. Effect on Number of J_2 in 1ml Soil

Like the number of galls, the number of J_2 (second stage juveniles) in the soil were also highly

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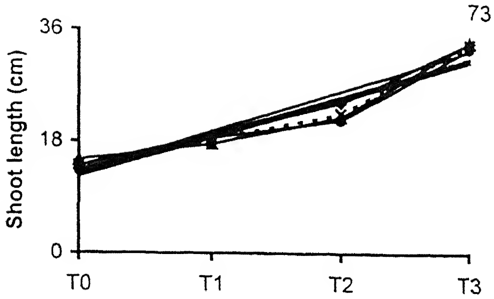

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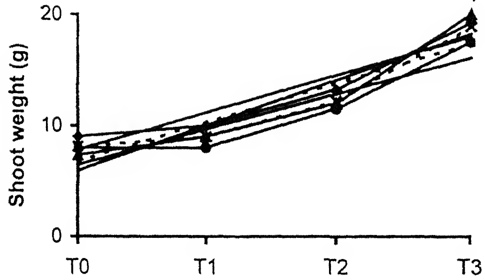

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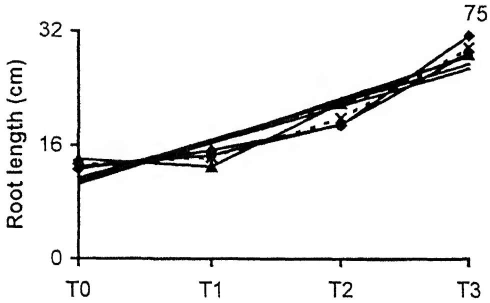

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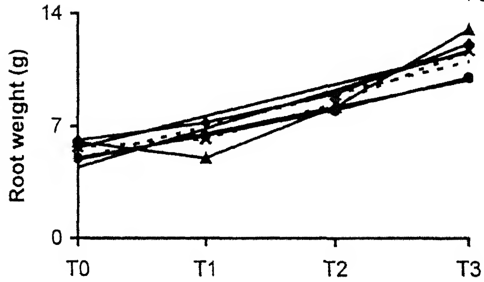

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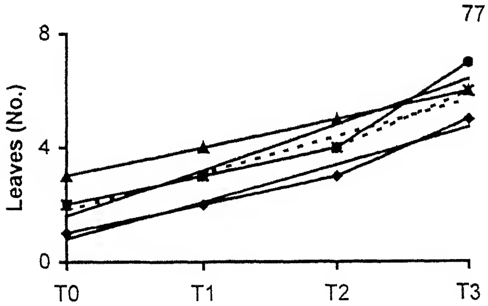

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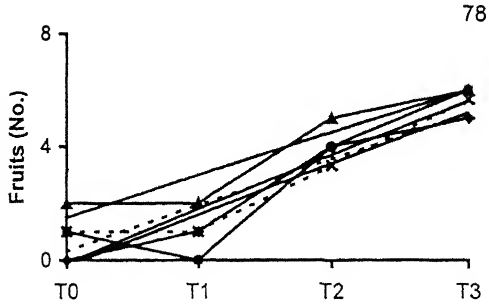

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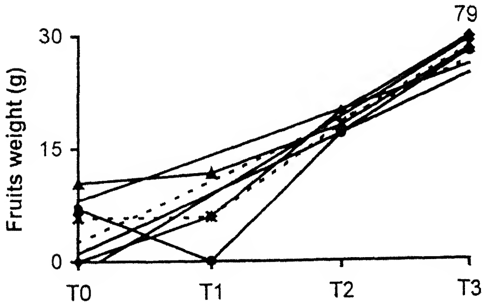

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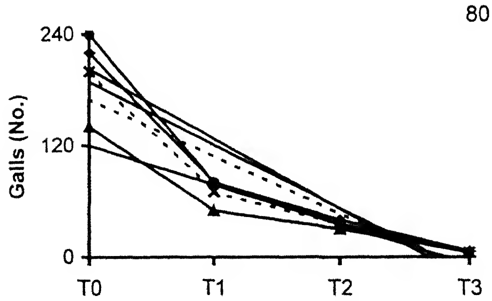


Table 11 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after pre-inoculation soil treatment one day before sowing by Fensulphothion (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 14.14 + 5.01 X	r = 0.749	$P < 0.100^S$
	R_2	Y = 13.06 + 4.88 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 13.56 + 4.92 X	r = 0.739	$P < 0.100^S$
	Mean	Y = 13.58 + 4.94 X	r = 0.747	$P < 0.100^S$
Shoot weight	R_1	Y = 8.21 + 2.65 X	r = 0.740	$P < 0.100^S$
	R_2	Y = 6.8 + 2.54 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 6.38 + 3.25 X	r = 0.740	$P < 0.100^S$
	Mean	Y = 7.13 + 2.81 X	r = 0.737	$P < 0.100^S$
Root length	R_1	Y = 11.13 + 4.84 X	r = 0.736	$P < 0.100^S$
	R_2	Y = 11.6 + 4.2 X	r = 0.738	$P < 0.100^S$
	R_3	Y = 12.2 + 4.17 X	r = 0.711	$P < 0.100^S$
	Mean	Y = 11.63 + 4.40 X	r = 0.736	$P < 0.100^S$
Root weight	R_1	Y = 5.92 + 1.53 X	r = 0.748	$P < 0.100^S$
	R_2	Y = 5.16 + 1.25 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 4.64 + 1.94 X	r = 0.701	$P < 0.100^S$
	Mean	Y = 5.24 + 1.57 X	r = 0.739	$P < 0.100^S$
Leaves (No.)	R_1	Y = 1 + 1 X	r = 0.750	$P < 0.100^S$
	R_2	Y = 1.8 + 1.25 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 3.2 + 0.74 X	r = 0.737	$P < 0.100^S$
	Mean	Y = 2 + 1 X	r = 0.750	$P < 0.100^S$
Fruits (No)	R_1	Y = 0 199 + 1.31 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 0.20 + 1.45 X	r = 0.677	$P < 0\ 200^S$
	R_3	Y = 1.8 + 1.11 X	r = 0.692	$P < 0.100^S$
	Mean	Y = 0.534 + 1.26 X	r = 0.726	$P < 0.100^S$
Fruit weight	R_1	Y = 0.380 + 7.76 X	r = 0.734	$P < 0.100^S$
	R_2	Y = 2 + 6.28 X	r = 0.660	$P < 0.200^S$
	R_3	Y = 8.84 + 4.73 X	r = 0.738	$P < 0.100^S$
	Mean	Y = 3.74 + 6.28 X	r = 0.723	$P < 0.100^S$
Galls (No.)	R_1	Y = 170.8 - 48.17 X	r = -0.656	$P < 0.200^S$
	R_2	Y = 182.2 – 52.82 X	r = -0.644	$P < 0.200^S$
	R_3	Y = 109 – 30.14 X	r = -0.656	$P < 0.200^S$
	Mean	Y = 154 – 43.7 X	r = -0.651	$P < 0.200^S$
J2 in 1ml soil (No.)	R_1	Y = 23 – 5.71 X	r = -0.720	$P < 0.100^S$
	R_2	Y = 20.4 – 5.08 X	r = -0.720	$P < 0.100^S$
	R_3	Y = 20.2 – 4.54 X	r = -0.718	$P < 0.100^S$
	Mean	Y = 20.2 – 4.54 X	r = -0.718	$P < 0.100^S$

reduced at 4Kg a.i./ha dosage in R_{10} replicates while minimum reduction was observed at 1Kg a. i./ha dosage in R_2 replicates. The reduction pattern was, however, significant ($P < 0.100$) [Fig. 81, Table 11]. But the pattern of decline here was in striking contrast to that observed in root galls. The tendency of decline for 1, 2 and 4Kg a.i./ha in J_2 larvae was uniform [Fig. 81] whereas it was abruptly sharp between control and 1Kg a.i./ha soil treatment by Fensulphothion, and the declines thereafter with 2 and 4Kg a.i./ha were not all that sharp as those observed in 1Kg a.i./ha treatment [Fig. 81].

B. Effect of Carbofuran

1. Effect on Shoot and Root Length, and Shoot and Root Weight

The growth in length of shoot of experimental plants were uniform in all the replicates with maximum shoot length at 4Kg a.i./ha dose in R_2 replicates, maximum shoot weight in R_1, maximum root length in R_1 and R_3, and maximum root weight in R_3 replicates at 4Kg a.i./ha. On the contrary, minimum growth occurred at 1Kg a.i./ha in R_1 replicates. The growth pattern was, however, significant ($P < 0.10$) [Fig. 82-85, Table 12].

2. Effect on Number of Leaves and Fruits

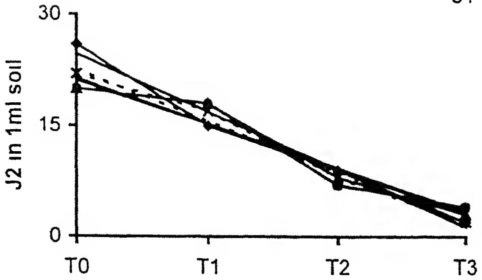
No change was observed at 1Kg a.i./ha treatment, but the rise was steep in number of leaves [Fig. 86] as well as number of fruits [Fig. 87] when 2Kg a. i. /ha soil treatment was compared with 4Kg a. i. /ha treatment plants. The linear regression trends thus exhibited a significant positive correlation of soil treatment by Carbofuran with the number of leaves as well as fruit production [Fig. 86, 87 Table 12].

3. Effect on Weight of Fruits

The 3 replicates showed varied patterns in potted plants with 1, 2 and 4Kg a.i./ha soil treatments while the incline in weight of fruits was gradual in R_1 replicates between 1, 2 and 4 Kg a.i./ha soil treatments plants. The rise in influence of 2Kg a.i./ha treatment over 1Kg a.i./ha treatment was significantly high in the former treatment than 4Kg a.i./ha treatment in R_3 replicates. However, conversely the growth in fruits was more significantly sharp in 4Kg a.i./ha treatment than 2Kg a.i./ha treatment in R_2 replicates [Fig. 88, Table 12].

4. Effect on Number of Galls and J2 Larvae

81



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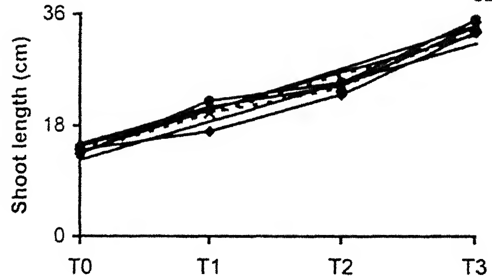

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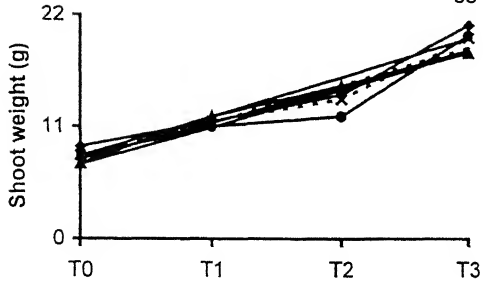

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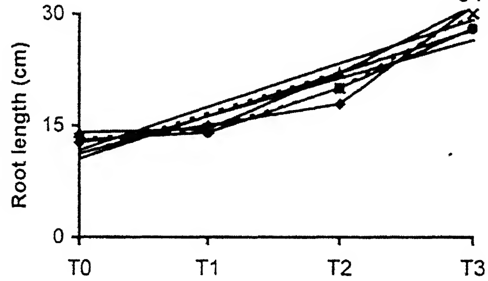

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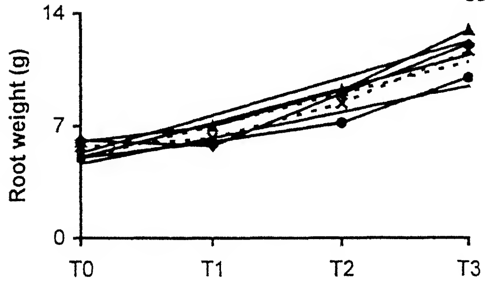

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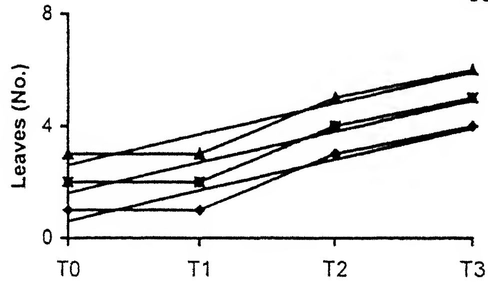

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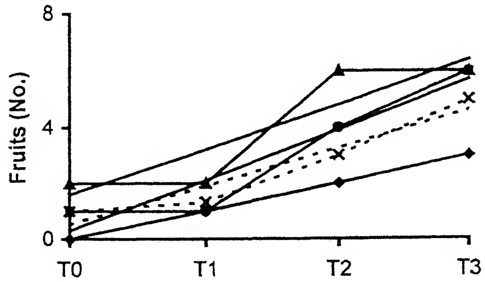

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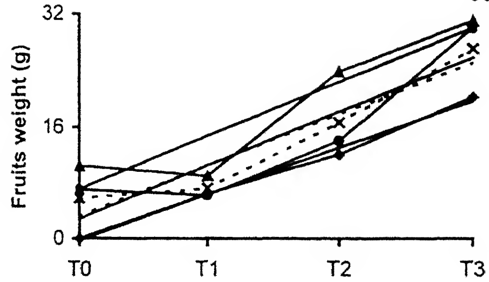


Table 12 : Linear regression trends depicting variations in *A. esculentus* characteristics infesting *M. incognita* after pre-inoculation soil treatment one day before sowing by Carbofuran (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 13.2 + 4.88 X	r = 0.746	$P < 0.100^S$
	R_2	Y = 14.78 + 5.16 X	r = 0.739	$P < 0.100^S$
	R_3	Y = 15.49 + 4.64 X	r = 0 747	$P < 0.100^S$
	Mean	Y = 14.49 + 4.89 X	r = 0.749	$P < 0.100^S$
Shoot weight	R_1	Y = 8.62 + 3.01 X	r = 0.747	$P < 0.100^S$
	R_2	Y = 7.60 + 2.94 X	r = 0.735	$P < 0.100^S$
	R_3	Y = 8.53 + 2.63 X	r = 0.724	$P < 0.100^S$
	Mean	Y = 8.25 + 2.86 X	r = 0.748	$P < 0.100^S$
Root length	R_1	Y = 10.93 + 4.67 X	r = 0.729	$P < 0.100^S$
	R_2	Y = 11.8 + 3.97 X	r = 0.737	$P < 0.100^S$
	R_3	Y = 12.4 + 4.55 X	r = 0.732	$P < 0.100^S$
	Mean	Y = 11.71 + 4.40 X	r = 0.737	$P < 0.100^S$
Root weight	R_1	Y = 5.34 + 1.65 X	r = 0.716	$P < 0.100^S$
	R_2	Y = 4.84 + 1.26 X	r = 0.747	$P < 0.100^S$
	R_3	Y = 5.64 + 1.80 X	r = 0.745	$P < 0\ 100^S$
	Mean	Y = 5.26 + 1.57 X	r = 0.740	$P < 0.100^S$
Leaves (No.)	R_1	Y = 8 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 1.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_3	Y = 2.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	Mean	Y = 1.8 + 0.82 X	r = 0.707	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.199 + 0.74 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 0.599 + 1 37 X	r = 0.717	$P < 0.100^S$
	R_3	Y = 2 + 1.14 X	r = 0.633	$P < 0.200^S$
	Mean	Y = 0.732 + 1.05 X	r = 0.738	$P < 0.100^S$
Fruit weights	R_1	Y = 0.900 + 5.01 X	r = 0.745	$P < 0.100^S$
	R_2	Y = 3.48 + 6.18 X	r = 0.717	$P < 0.100^S$
	R_3	Y = 8.39 + 5.8 X	r = 0.697	$P < 0.100^S$
	Mean	Y = 4.26 + 5.66 X	r = 0.735	$P < 0.100^S$
Galls (No.)	R_1	Y = 169 – 48.71 X	r = -0.649	$P < 0.200^S$
	R_2	Y = 177.4 – 52.3 X	r = -0.630	$P < 0.200^S$
	R_3	Y = 118 – 31.42 X	r = -0.702	$P < 0.100^S$
	Mean	Y = 154.8 – 44.1 X	r = -0.655	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 22.2 – 5.6 X	r = -0.699	$P < 0.200^S$
	R_2	Y = 17.2 – 4.11 X	r = -0.704	$P < 0.200^S$
	R_3	Y = 16.8 – 3.74 X	r = -0.676	$P < 0.200^S$
	Mean	Y = 18.8 – 4.6 X	r = -0.702	$P < 0.100^S$

The sudden reduction occurred in the number of root- knot galls in experimental plants, whose soils were first treated with 1Kg a.i./ha Carbofuran. The effect of nematicide thereafter stabilized at higher dosages (2 and 4 Kg a.i./ha) of soil treatment ($P < 0.20$) [Fig. 89, 90, Table 12].

C. Effect of Mocap

1. Effect on Shoot and Root Length, and Shoot and Root Weight

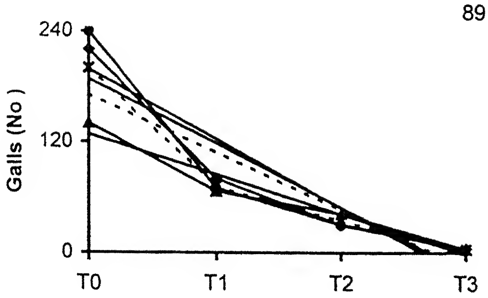
The effect of treatment of soil with Mocap in potted plants showed a remarkable increase at 4Kg a.i./ha. dose than 1 or 2Kg a.i./ha. The sudden rise in curve between 2 and 4Kg/ ha treatment was in evidence in shoot length and weight ($P < 0.10$) as well as in root length ($P < 0.10$) and weight ($P < 0.20$ - $P < 0.10$). The linear regression trends confirmed significant increased influence of enhanceded strength of nematicide to adversely affect the nemic population in soil around ***A. esculentus*** which could thus favourably influence the aforementioned root and shoot growth parameters. ($P < 0.20$ - $P < 0.10$) [Fig. 91-94, Table 13].

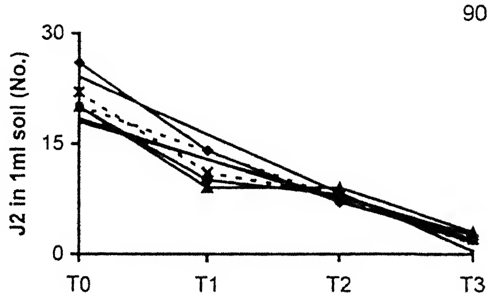
2. Effect on Number of Leaves

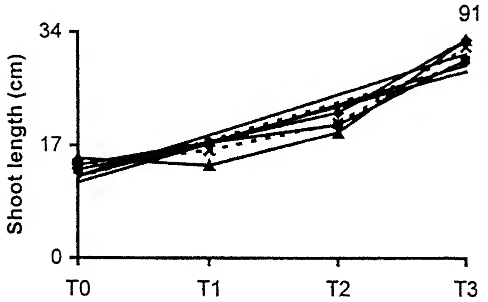
There were wide variations observed at different dosages of Mocap with maximum number exhibited at 4Kg a.i./ha in R_2 and R_3 replicates, while minimum number of leaves were recorded at 1Kg a.i./ha in R_1 & R_2 replicates. At 2Kg a.i./ha, maximum numbers were observed in R_2 replicates, ($P < 0.20 - 0.10$) [Fig. 95, Table 13]. Therefore, the higher dosages of 2 and 4Kg a.i./ha were critically significant in soil treatment for control of infestations that resultantly produced greater number of leaves in potted plants.

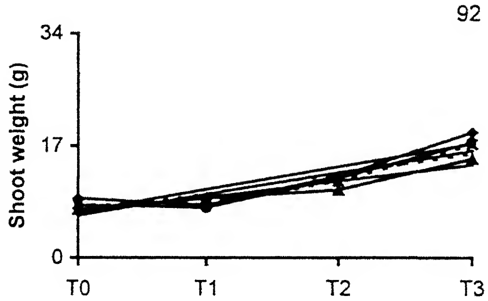
3. Effect on Number and Weight of Fruits

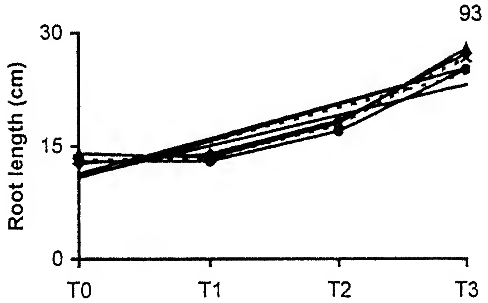
In the quantitative assessment of the number of fruits, variations were observed at different dosages. The maximum number occured at 4Kg a.i./ha in R_3 replicates while no fruits were produced at 1Kg a.i./ha in R_1 replicates. Significant level ($P < 0.100$) [Fig. 96, Table 13]. Therefore, similar to the results in production of leaves in the preceding text, the higher dosages of 2 and 4Kg a.i./ha soil treatment by Mocap were critically significant in enhancement of the fruit yield as well as weight of fruits [Fig. 96-97, Table 13].

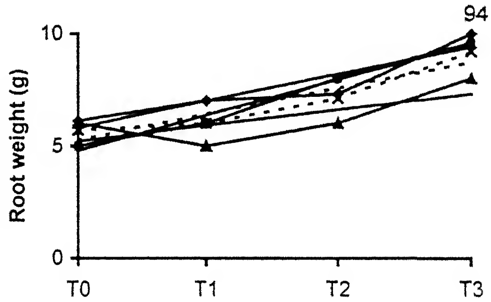

89
Galls (No)
240
120
0
T0
T1
T2
T3

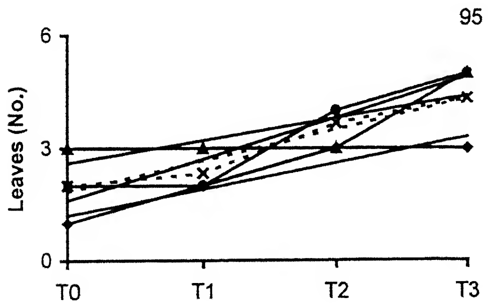

90
J2 in 1ml soil (No.)
30
15
0
T0
T1
T2
T3


91
Shoot length (cm)
34
17
0
T0
T1
T2
T3


92
Shoot weight (g)
34
17
0
T0
T1
T2
T3


93
Root length (cm)
30
15
0
T0
T1
T2
T3


94
Root weight (g)
10
5
0
T0
T1
T2
T3


95
Leaves (No.)
6
3
0
T0
T1
T2
T3

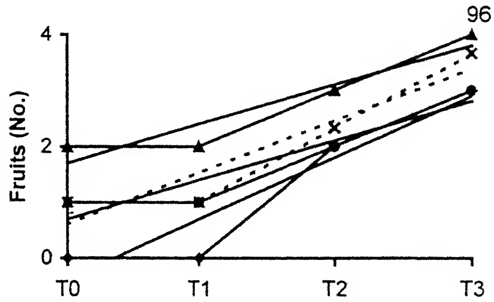

96
Fruits (No.)
4
2
0
T0
T1
T2
T3

Table 13 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after pre-inoculation soil treatment one day before sowing by Mocap (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 13.2 + 4.81 X	r = 0.746	$P < 0.100^S$
	R_2	Y = 12.98 + 4.14 X	r = 0.746	$P < 0.100^S$
	R_3	Y = 11.8 + 4.82 X	r = 0.705	$P < 0.100^S$
	Mean	Y = 12.66 + 4.59 X	r = 0.738	$P < 0.100^S$
Shoot weight	R_1	Y = 7.28 + 2.75 X	r = 0.709	$P < 0.100^S$
	R_2	Y = 6.77 + 2.58 X	r = 0.721	$P < 0.100^S$
	R_3	Y = 7.04 + 1.92 X	r = 0.744	$P < 0.100^S$
	Mean	Y = 7.03 + 2.41 X	r = 0.729	$P < 0.100^S$
Root length	R_1	Y = 11.38 + 3.82 X	r = 0.739	$P < 0.100^S$
	R_2	Y = 11.35 + 3.26 X	r = 0.724	$P < 0.100^S$
	R_3	Y = 11.8 + 3.75 X	r = 0.715	$P < 0.100^S$
	Mean	Y = 11.51 + 3.61 X	r = 0.727	$P < 0.100^S$
Root weight	R_1	Y = 5.92 + 0.96 X	r = 0 732	$P < 0.100^S$
	R_2	Y = 5.08 + 1.18 X	r = 0.737	$P < 0.100^S$
	R_3	Y = 5.2 + 0.6 X	r = 0.610	$P < 0.200^S$
	Mean	Y = 3.4 + 0.91 X	r = 0.738	$P < 0.100^S$
Leaves (No.)	R_1	Y = 1.4 + 0.48 X	r = 0.649	$P < 0\ 200^S$
	R_2	Y = 1.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_3	Y = 2.6 + 0.51 X	r = 0.658	$P < 0.200^S$
	Mean	Y = 1.99 + 0.61 X	r = 0.720	$P < 0.100^S$
Fruits (No.)	R_1	Y = -0.20 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 1.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 1 8 + 0.54 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 0.734 + 0.72 X	r = 0.726	$P < 0.100^S$
Fruit weights	R_1	Y = -1 + 5.28 X	r = 0.694	$P < 0.100^S$
	R_2	Y = 5.92 + 2.84 X	r = 0.689	$P < 0.100^S$
	R_3	Y = 8.08 + 1.89 X	r = 0.598	$P < 0.200^S$
	Mean	Y = 4.22 + 3.37 X	r = 0.710	$P < 0.100^S$
Galls (No.)	R_1	Y = 168.4 – 47.9 X	r = -0.644	$P < 0.200^S$
	R_2	Y = 181.2 – 52.2 X	r = -0.641	$P < 0.200^S$
	R_3	Y = 113.4 – 30.51 X	r = -0.679	$P < 0.200^S$
	Mean	Y = 154.2 – 43.4 X	r = -0.651	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 25.4 – 6.22 X	r = -0.727	$P < 0.100^S$
	R_2	Y = 22.4 – 4.65 X	r = -0.677	$P < 0.200^S$
	R_3	Y = 18.8 – 4.02 X	r = -0.737	$P < 0.100^S$
	Mean	Y = 22.2 – 4.97 X	r = -0.735	$P < 0.100^S$

4. Effect on Number of Galls

It was highly reduced at 4Kg a.i./ha in all the replicates, while minimum reduction were found in R_2 replicates at 1Kg a.i./ha. The reduction pattern in galls' number was statistically significant ($P < 0.20$) [Fig. 98, Table 13]. Therefore, significant reduction in the number of root-knot galls was achieved at 1Kg a.i./ha dosage of soil treatment, than at the higher dosages (2 and 4Kg a. i. / ha).

5. Effect on Number of J_2 in 1ml Soil

The decline in J_2 stage larvae in the potted plant experiments with Mocap treated soil was gradual with the increase in 2 to 4Kg a.i./ha nematicide concentration increase [Fig. 99, Table 13].

D. Effect of Phorate

1. Effect on Shoot and Root Length and Shoot Weight

No wide variations were observed in all the replicates with soil treated with Phorate. Maximum growth

in the length of shoot was encountered in R_1 replicates at 4Kg a.i./ha. The sharp rise in length ($P < 0.100$) as well as weight ($P < 0.100$) of the shoot along with length of root ($P < 0.20$ - $P < 0.10$) at 4Kg a.i./ha could be demarcated comparably with relatively slower growth in these parameters at 1 and 2Kg a.i./ha soil treatments [Figs. 100-102, Table 14].

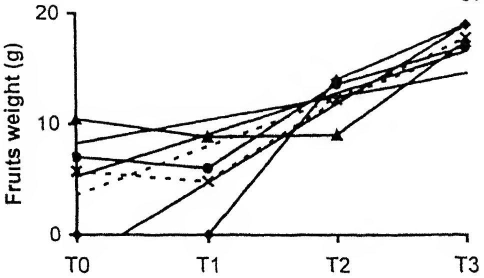
2. Effect on Root Weight

The sharp incline in root weight of R_1 replicate at 4 Kg a.i./ha was very well marked in comparison to lower concentration of soil treatment at 1 or 2Kg a.i./ha ($P < 0.10$) [Fig. 103]. The trends of scatter plots at 1 and 2 Kg a.i./ha were contradictory but a subtle rise resulted thereafter in the other 2 replicates, R_2 and R_3 ($P < 0.200$ - 0.100, [Fig. 103, Table 14].

3. Effect on Number of Leaves and Fruits

A noticeable increase in number of leaves ($P < 0.100$, Fig. 104, Table 14) and fruits ($P < 0.200$ - $P < 0.100$, Fig. 105, Table 14) could be recorded at 2 and 4Kg a.i./ha soil treatment. The treatment at 1Kg a.i./ha for the growth in the number of leaves and 2 Kg a.i./ha as

97



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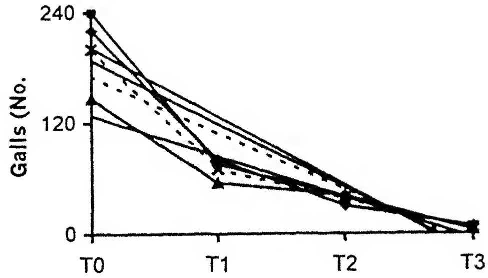

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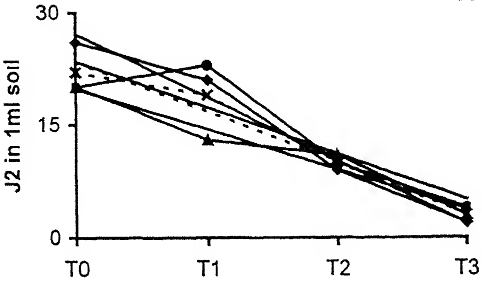

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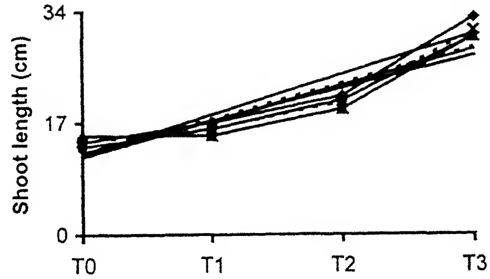

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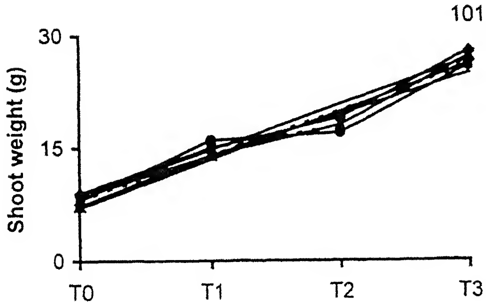

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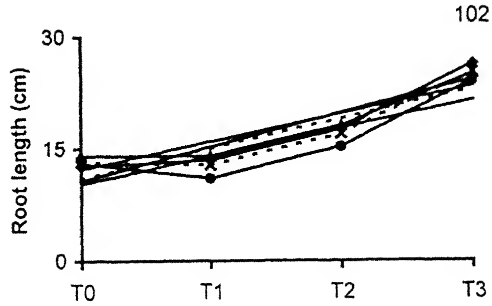

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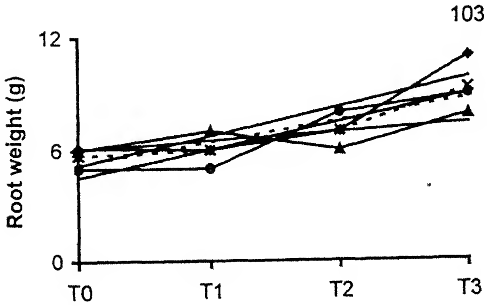

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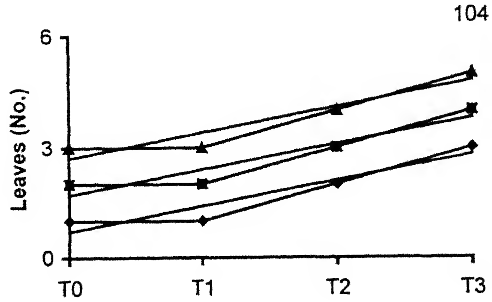

well in R_3 replicate in the growth of number of fruits did not show marked influence on nemic population.

4. Effect on Weights of fruits

The maximum weight of fruits were achieved at 4 Kg a.i./ha in R_1 replicates, while minimum weight of fruits were recorded at 1Kg a.i./ha in R_3 replicates ($P < 0.20 - P < 0.10$) [Fig. 106, Table 14].

5. Effect on the Number of Galls

All the replicates exhibited maximum reduction in the galls of roots of experimental plants at 1Kg a.i./ha. The pattern of reduction of galls thereafter slowed down at 2 and 4 Kg a.i./ha, however, minimum galls were observed in the roots of potted plants possessing soil treated with 4 Kg a.i./ha nematicide ($P < 0.20 - P < 0.10$) [Fig. 107, Table 14].

6. Effect on J_2 in 1ml Soil

The trend of reduction in the density of J_2 stage larvae was very sharp in the potted plants treated with 2 and 4Kg a.i./ha Phorate ($P < 0.10$, Fig. 108, Table 14).

Table 14 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after pre-inoculation soil treatment one day before sowing by Phorate (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 12.8 + 4.82 X	r = 0.741	$P < 0.100^S$
	R_2	Y = 12.44 + 4.26 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 12.8 + 3.97 X	r = 0.717	$P < 0.100^S$
	Mean	Y = 12.68 + 4.35 X	r = 0.737	$P < 0.100^S$
Shoot weight	R_1	Y = 9.60 + 4.65 X	r = 0.748	$P < 0.100^S$
	R_2	Y = 9.40 + 4.2 X	r = 0.730	$P < 0.100^S$
	R_3	Y = 8.12 + 4.87 X	r = 0.746	$P < 0.100^S$
	Mean	Y = 9.03 + 4.57 X	r = 0.744	$P < 0.100^S$
Root length	R_1	Y = 11.16 + 3.59 X	r = 0.733	$P < 0.100^S$
	R_2	Y = 10.44 + 3.06 X	r = 0.684	$P < 0.200^S$
	R_3	Y = 12.6 + 2.94 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 11 4 + 3.2 X	r = 0.718	$P < 0.100^S$
Root weight	R_1	Y = 5.26 + 1.29 X	r = 0.702	$P < 0.100^S$
	R_2	Y = 4.8 + 1.11 X	r = 0.692	$P < 0.100^S$
	R_3	Y = 6.02 + 0.40 X	r = 0.564	$P < 0.200^S$
	Mean	Y = 5.36 + 0.93 X	r = 0.735	$P < 0.100^S$
Leaves (No.)	R_1	Y = 0.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	R_2	Y = 1.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 2.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 1.8 + 0.54 X	r = 0.726	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.19 + 0.74 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 0.8 + 0.82 X	r = 0.707	$P > 0.100^S$
	R_3	Y = 0.8 + 0.82 X	r = 0.560	$P < 0.200^S$
	Mean	Y = 0.6 + 0.8 X	r = 0.724	$P < 0.100^S$
Fruit weights	R_1	Y = 0.60 + 5.65 X	r = 0.748	$P < 0.100^S$
	R_2	Y = 4.92 + 3.51 X	r = 0.715	$P < 0.100^S$
	R_3	Y = 6.24 + 3.09 X	r = 0.608	$P < 0.200^S$
	Mean	Y = 3.92 + 4.08 X	r = 0.728	$P < 0.100^S$
Galls (No.)	R_1	Y = 175.8 – 48.7 X	r = -0.670	$P < 0.200^S$
	R_2	Y = 181.4 - 52.2 X	r = -0.641	$P < 0.200^S$
	R_3	Y = 116.2 – 31.5 X	r = -0.691	$P < 0.100^S$
	Mean	Y = 157.8 – 44.17 X	r = -0.664	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 25.6 – 6.34 X	r = -0.715	$P < 0.100^S$
	R_2	Y = 21.4 – 4.51 X	r = -0.692	$P < 0.100^S$
	R_3	Y = 20.8 – 4.31 X	r = -0.745	$P < 0.100^S$
	Mean	Y = 22.6 – 5.05 X	r = -0.729	$P < 0.100^S$

The concentration of nematicide in soil 1 Kg a.i./ha did not showed marked influence on decline in J_2 stage larvae.

E. Effect of Aldicarb

1. Effect on Shoot Length and weight

The effect of the three doses of Aldicarb revealed sharp increase in shoot length and weight at 4Kg a.i./ha but subtle incline at 2Kg a.i./ha soil treatment concentration in length and weight of shoot. [Fig. 109, 110, Table 15]. The maximum growth and weight of shoot occurred at 4Kg a.i./ha in R_1 replicates and minimum growth in shoot length was recorded at 1Kg a.i./ha in R_2 replicates, while minimum shoot weight was encountered at 1Kg a.i./ha in R_2 and R_3 replicates.

2. Effect on Root Length and Weight

The maximum growth length of root was exhibited at 4Kg a.i./ha in R_2 replicate, while minimum growth were encountered at 1Kg a.i./ha in R_3 replicates. At 2Kg a.i./ha minimum growth was observed in R_2

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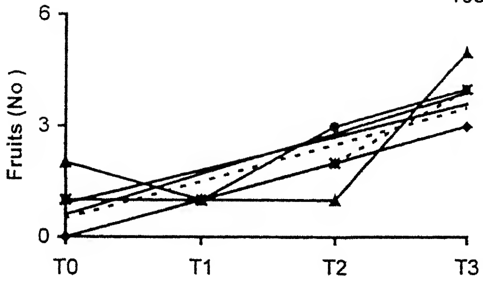

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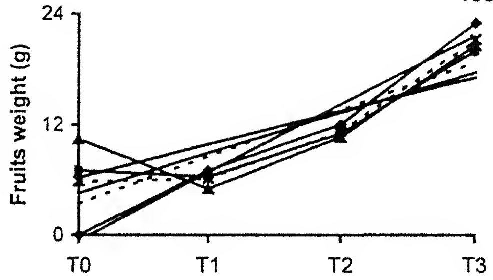

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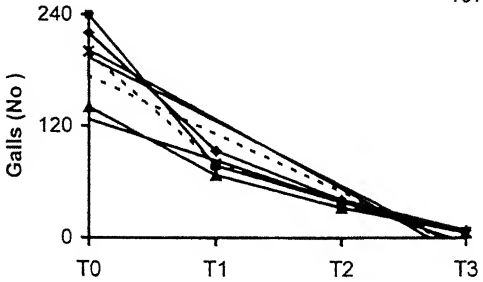

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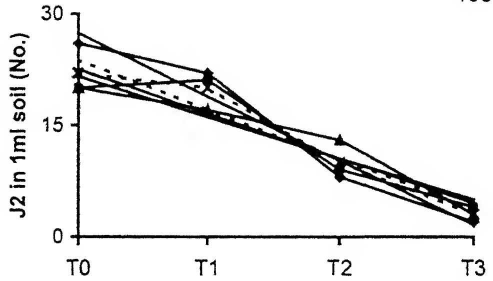

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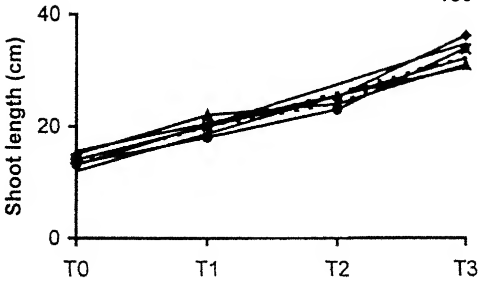

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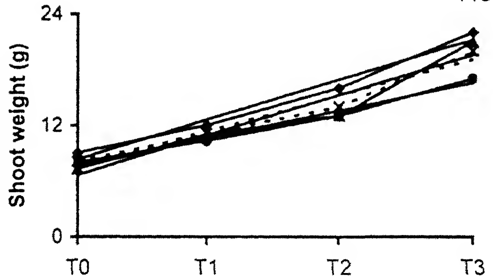

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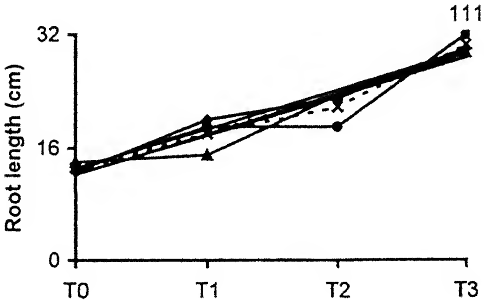

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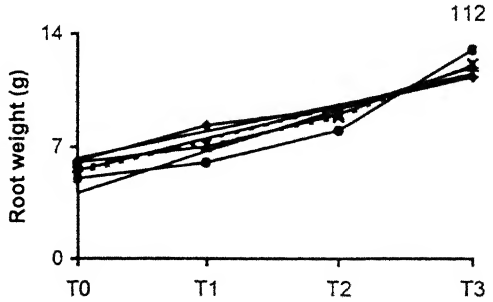

replicates. As would be evident from the trend of growth in root length and weight in the scatterplots, the growth was substantial at 4Kg a.i./ha treatment in comparison to no effect recorded by 2Kg a.i./ha on root length and a gradually slower increasing effect by 2Kg a.i./ha on root weight ($P < 0.100$, Fig. 111, 112, Table 15).

3. Effect on Number of Leaves and Fruit and Weight of fruits

A uniform increase in the number of leaves and fruits as well as weight of fruits with increasing dosage of Aldicarb occurred. The R_3 replicate exhibited maximum number of fruits in R_2, and highest fruit weight was encountered in R_1 replicates at 4Kg a.i./ha dosage of Aldicarb The minimum number of leaves and fruits were reported in R_1 replicates at 1Kg a.i./ha, but minimum fruits weight was encountered at 1Kg a.i./ha in R_3 replicates. ($P < 0.100$) [Fig. 113-115, Table 15].

4. Effect on Number of Galls

There was an abrupt decline in the number of root-knot galls at 1Kg a.i./ha soil treatment by Aldicarb in all the three replicates R_1, R_2 and R_3. The reduction

Table 15 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after pre-inoculation soil treatment one day before sowing by Aldicarb (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 14.21 + 5.53 X	r = 0.749	$P < 0.100^S$
	R_2	Y = 12.98 + 5.19 X	r = 0.749	$P < 0.100^S$
	R_3	Y = 16 4 + 3.77 X	r = 0.733	$P < 0.100^S$
	Mean	Y = 14.53 + 4.83 X	r = 0.748	$P < 0.100^S$
Shoot weight	R_1	Y = 9 + 3.28 X	r = 0.748	$P < 0.100^S$
	R_2	Y = 8.12 + 2.26 X	r = 0.748	$P < 0\ 100^S$
	R_3	Y = 7.18 + 3.36 X	r = 0.745	$P < 0.100^S$
	Mean	Y = 8.10 + 2.97 X	r = 0.749	$P < 0.100^S$
Root length	R_1	Y = 14 16 + 4.13 X	r = 0.735	$P < 0.100^S$
	R_2	Y = 12.8 + 4.54 X	r = 0.725	$P < 0.100^S$
	R_3	Y = 13.18 + 4.16 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 13.38 + 4.28 X	r = 0.749	$P < 0.100^S$
Root weight	R_1	Y = 6.6 + 1.24 X	r = 0.733	$P < 0.100^S$
	R_2	Y = 4.4 + 2 05 X	r = 0.740	$P < 0.100^S$
	R_3	Y = 5.8 + 1.54 X	r = 0.746	$P < 0.100^S$
	Mean	Y = 5.59 + 1.61 X	r = 0.749	$P < 0.100^S$
Leaves (No.)	R_1	Y = 1.2 + 0.74 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 2.2 + 0.74 X	r = 0.737	$P < 0.100^S$
	R_3	Y = 3.2 + 0.74 X	r = 0.737	$P > 0.100^S$
	Mean	Y = 2.2 + 0.74 X	r = 0.737	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.39 + 1.48 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 1.2 + 1.74 X	r = 0.747	$P < 0.100^S$
	R_3	Y = 2.6 + 1.22 X	r = 0.709	$P < 0.100^S$
	Mean	Y = 1.4 + 1.48 X	r = 0.737	$P < 0.100^S$
Fruit weights	R_1	Y = 2.80 + 10.11 X	r = 0.723	$P < 0.100^S$
	R_2	Y = 6.66 + 8.19 X	r = 0.727	$P < 0.100^S$
	R_3	Y = 8.84 + 7.32 X	r = 0.716	$P < 0.100^S$
	Mean	Y = 5.81 + 8.56 X	r = 0.728	$P < 0.100^S$
Galls (No.)	R_1	Y = 160.8 – 47.88 X	r = -0.623	$P < 0.200^S$
	R_2	Y = 170 – 51.28 X	r = -0.603	$P < 0.200^S$
	R_3	Y = 105.4 – 30.08 X	r = -0.636	$P < 0.200^S$
	Mean	Y = 145.4 – 43.08 X	r = -0.618	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 22.6 – 6.05 X	r = -0.706	$P < 0.100^S$
	R_2	Y = 16.6 – 4.2 X	r = -0.681	$P < 0.200^S$
	R_3	Y = 17.2 – 3.97 X	r = -0.699	$P < 0.200^S$
	Mean	Y = 18.8 – 4.74 X	r = -0.698	$P < 0.200^S$

thereafter, slowed down at 2 and 4Kg a.i./ha ($P < 0.100$) [Fig. 116, Table 15].

5. Effect on J_2 in 1ml Soil

A gradual declining effect was recorded in the number of J_2 stage larvae and soil at 1, 2 and 4 Kg a.i./ha treatment of soil by Aldicarb in experiments with potted plants ($P < 0.100$, Fig. 117, Table 15).

F. Effect of Acephate

1. Effect on Shoot Length and Weight and Root Length

The maximum growth in length of shoot ($P < 0.100$), weight ($P < 0.200$) of shoot as well as root length ($P < 0.200$ - $P < 0.100$) in the experimental plants were recorded at 4Kg a.i./ha in R_1 replicates ($P < 0.100$, Figs. 118-120, Table 16). The peculiar feature of these investigations was a decline at 1Kg a.i./ha, stabilized growth in all of the 3 plant growth parameters at 2Kg a.i./ha, and a sharp incline in growth at 4Kg a.i./ha in the shoot as well as root growth parameters in R_3 replicates.

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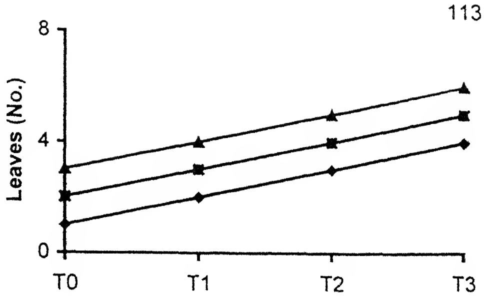

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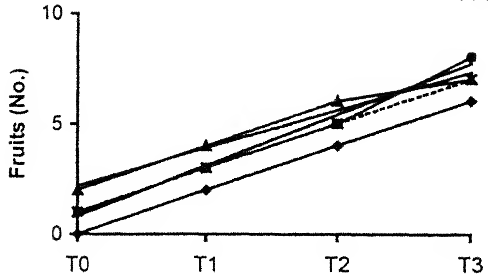

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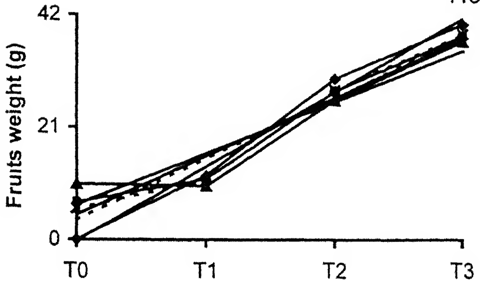

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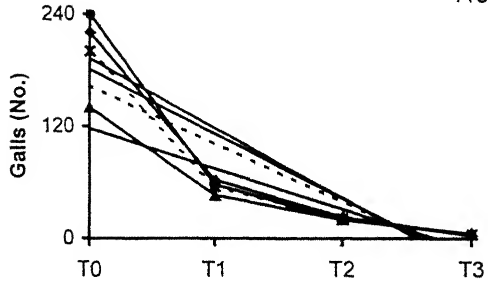

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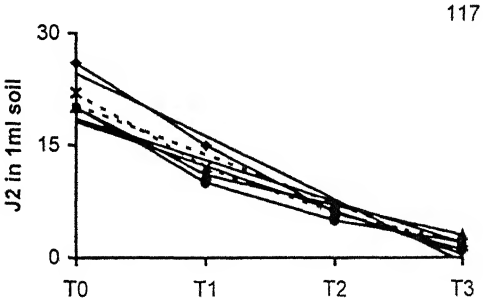

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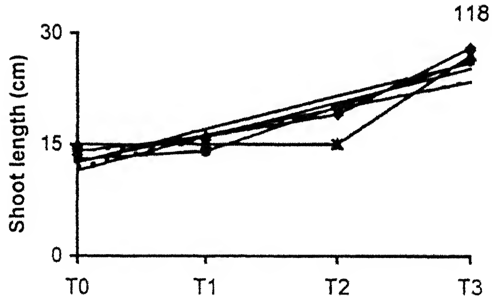

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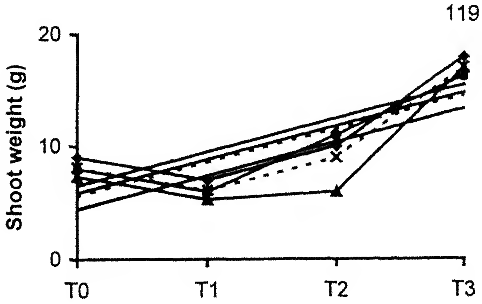

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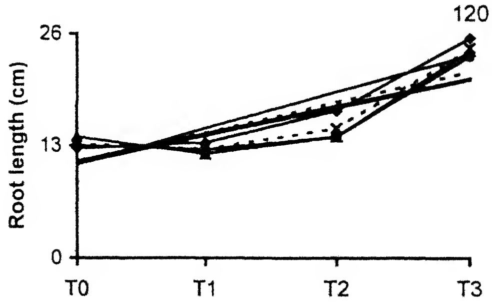

On the other hand, after an initial decline at 1Kg a.i./ha, a uniform increasing trend was observed in these growth parameters at 2 and 4 Kg a.i./ha.

2. Effect on Root Weight

The soil treatment concentration of Acephate at 2Kg a.i./ha exhibited maximum influence on nemic control. Thereafter, the growth in root weight in 3 replicates was marginal but the peak was obtained at 4Kg a.i./ha ($P < 0.10$, Fig. 121, Table 16). A gradual uniform inclining trend was noticed in the other 2 replicates, R_1 and R_2.

3. Effect on Number of Leaves and Fruits and Weight of Fruits

Wide variations were observed in R_2 and R_3 replicates at different dosages of Acephate. But for the abrupt growth in the number of leaves at 4Kg a.i./ha, the dosage appeared a favourable one for number of leaves, and fruits. The varied levels of significance, therefore, were obvious **viz.** significantly in R_1 and R_2 replicates ($P < 0.20$) and non-significant ($P > 0.50$) in R_3 replicates showing high significance at individual level but poor

agreement between the 3 replicates for observations on number of leaves [Fig. 122, Table 16]. Similarly the growth was non-significant in R_2 ($P > 0.500$) but significant in R_1 and R_3 for the growth of number of fruits ($P < 0.200$) [Fig. 123, Table 16]. Subsequently, growth pattern was uniformly significant ($P < 0.200$) [Fig. 124, Table 16] for the weight of fruits.

4. Effect on Number of Galls

The number of galls reduced immediately at the introduction of 1Kg a.i./ha in all the replicates R_1, R_2 and R_3 and such decline in root-knot galls continued further at the application of 2 and 4 Kg a.i./ha [Fig. 125, Table 16].

5. Effect on Number of J_2 in 1ml Soil

The trend, however, was markedly different in the reduction of J_2 stage larvae than the disappearance of root-knot galls at the introduction of 1Kg a.i./ha soil treatment. No change was observed on 1Kg a.i./ha but thereafter significant gradual decline in J_2 stage larvae population was observed at 2 and 4Kg a.i./ha till the minimum level was achieved at 4Kg a.i./ha ($P < 0.100$) [Fig. 126, Table 16].

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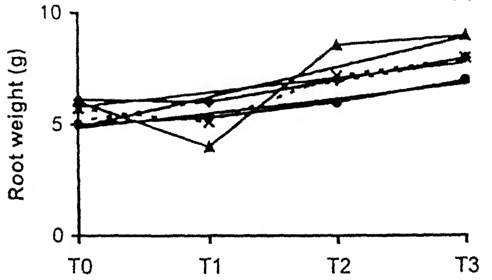

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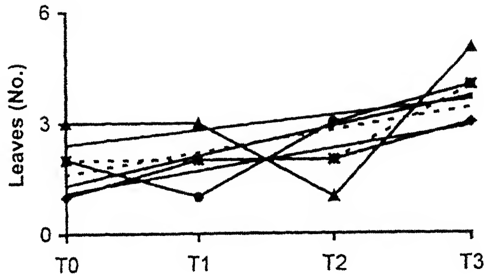

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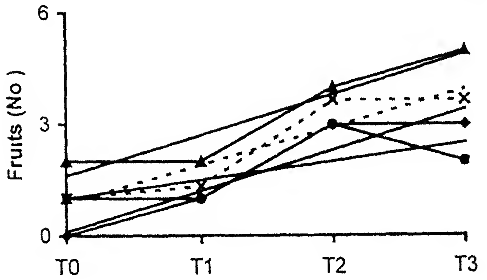

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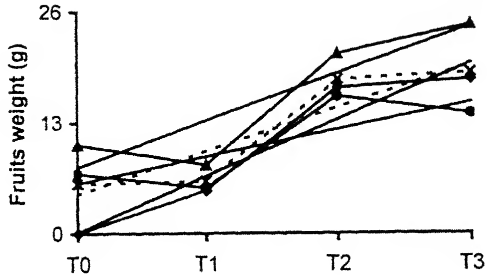

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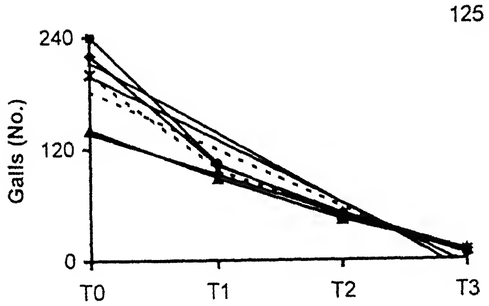

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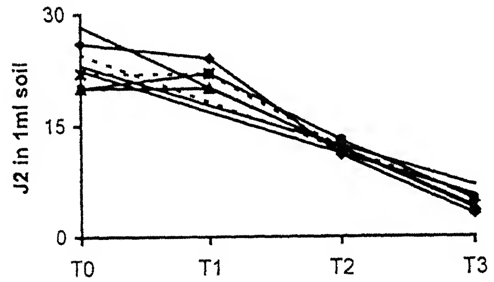

Table 16 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after pre-inoculation soil treatment one day before sowing by Acephate (1kg., 2kg., 4kg per ha.) (s = significant, J_2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 13 + 3.57 X	r = 0.739	$P < 0.100^S$
	R_2	Y = 12 14 + 3.53 X	r = 0.736	$P < 0.200^S$
	R_3	Y = 12.6 + 3.08 X	r = 0.658	$P < 0.100^S$
	Mean	Y = 12.64 + 3.37 X	r = 0.728	$P < 0.100^S$
Shoot weight	R_1	Y = 6.6 + 2.51 X	r = 0.666	$P < 0.200^S$
	R_2	Y = 6.14 + 2.39 X	r = 0.683	$P < 0.200^S$
	R_3	Y = 4.29 + 2.62 X	r = 0.616	$P < 0.200^S$
	Mean	Y = 5.68 + 2.51 X	r = 0.664	$P < 0.200^S$
Root length	R_1	Y = 11.18 + 3.38 X	r = 0.731	$P < 0.100^S$
	R_2	Y = 10.92 + 2.74 X	r = 0.682	$P < 0.200^S$
	R_3	Y = 11.2 + 2.74 X	r = 0.648	$P < 0.200^S$
	Mean	Y = 11.1 + 2.95 X	r = 0.695	$P < 0.100^S$
Root weight	R_1	Y = 5.86 + 0.522 X	r = 0.718	$P < 0.100^S$
	R_2	Y = 4.92 + 0.51 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 5.12 + 1.01 X	r = 0.555	$P < 0.200^S$
	Mean	Y = 5.3 + 0.68 X	r = 0.658	$P < 0.200^S$
Leaves (No.)	R_1	Y = 1.2 + 0.45 X	r = 0.717	$P < 0.100^S$
	R_2	Y = 1.4 + 0.62 X	r = 0.623	$P < 0.200^S$
	R_3	Y = 2.2 + 0.45 X	r = 0.358	$P > 0.50^{NS}$
	Mean	Y = 1.6 + 0.51 X	r = 0.658	$P < 0.200^S$
Fruits (No.)	R_1	Y = 0.4 + 0.77 X	r = 0.658	$P < 0.200^S$
	R_2	Y = 1.2 + 0.31 X	r = 0.420	$P > 0.50^{NS}$
	R_3	Y = 1.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	Mean	Y = 1.1 + 0.73 X	r = 0.647	$P < 0.200^S$
Fruit weights	R_1	Y = 1 8 + 4.6 X	r = 0.673	$P < 0.200^S$
	R_2	Y = 6 72 + 2.20 X	r = 0.540	$P < 0.200^S$
	R_3	Y = 8.76 + 4.10 X	r = 0.659	$P < 0.200^S$
	Mean	Y = 5.76 + 3.66 X	r = 0.652	$P < 0.200^S$
Galls (No.)	R_1	Y = 181 – 48.7 X	r = -0.685	$P < 0.200^S$
	R_2	Y = 193.4 – 5.38 X	r = -0.675	$P < 0.200^S$
	R_3	Y = 126 – 31.7 X	r = -0.721	$P < 0.100^S$
	Mean	Y = 166.8 – 44.7 X	r = -0.692	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 26.8 – 6.71 X	r = -0.723	$P < 0.100^S$
	R_2	Y = 22.4 – 4.22 X	r = -0.703	$P < 0.100^S$
	R_3	Y = 21.6 – 4.34 X	r = -0.726	$P < 0.100^S$
	Mean	Y = 23.6 – 4.91 X	r = -0.722	$P < 0.100^S$

Comparison of Different Nematicides Used as Soil Treatment One Day Before Sowing Against *M. incognita* on *A. esculentus*

The ANOVA was applied to data obtained from the application of nematicides in soil, one day before sowing of ***A. esculentus***. The comparison of different doses of all the nematicides were based on the value of three replicates of the experimental plants. Further, the comparative trends emerging from ANOVA were substantiated by the evaluation of efficacy of all the 6 nematicides in terms of growth parameters. The tool of Critical Difference (CD) was employed. The mean values of the three replicates have been mentioned in parentheses in the foregoing text.

1. Effect on Shoot Length

The statistical evaluation of data on shoot length revealed high degree of significance by ANOVA ($F_{2, 18}$ = 58.86). The maximum growth on treatment with different nematicides was recorded @ 4Kg a.i./ha in the following sequence:-

Carbofuran (34.00 cm) > Fensulphothion (33.80 cm) > Aldicarb (33.75 cm) > Mocap (32.00 cm) > Phorate (31.00 cm) > Acephate (27.10 cm).

The least effective doses were- 1 Kg a.i./ha Acephate (15.00 cm) < 1 Kg a.i./ha Phorate (16.00 cm) over untreated control (14.10 cm) on the basis of $CD_{5\%}$ = 2.55 and $CD_{1\%}$ = 3.44. The results of ANOVA are given as below:-

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	2500.12	138.89	58.86	1.99
Replication	2	11.86	5.93		

SE = 1.25 $CD_{5\%}$ = 2.55 $CD_{1\%}$ = 3.44

2. Effect on Shoot Weight

The data on shoot weight revealed that all the treatments at 2 and 4Kg a.i./ha were statistically significant and superior ($F_{2,18}$ = 59.57). The maximum growth of shoot weight was recorded at 4 Kg a.i./ha. The order of efficacy of different nematicides follows:-

Aldicarb (27.10 g) > Carbofuran (20.00 g) > Fensulphothion (19.75 g) > Phorate (18,90 g) > Mocap (17.15 g) > Acephate (17.10 g).

The least effective nematicides were 1 Kg a. i. /ha Aciphate (6.12 g) and 1 Kg a. i. /ha Carbofuran (8.20 g) over untreated control (8.10 g) $CD_{5\%}$ = 1.98 $CD_{1\%}$ = 2.67. The results of ANOVA are as follows: -

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	1516.56	84.25	59.57	1.99
Replication	2	22.74	11.37		

SE = 0.971 $CD_{5\%}$ = 1.98 $CD_{1\%}$ = 2.67

3. Effect on Root Length

The statistical evaluation of data on root length on the basis of ANOVA ($F_{2,18}$ = 61.35) showed that the growth was highly significant and superior at 4Kg a. i. /ha dosage. The order of their superiority was-

Aldicarb (30.50 cm) > Carbofuran (30.00 cm) > Fensulphothion (29.95 cm) > Mocap (26.85 cm) > Phorate (25.10 cm) > Acephate (24.30 cm).

The least effective nematicides were 1 Kg a. i. /ha Acephate (12.60 cm), 1 Kg a. i. /ha Phorate (12.80 cm) and 1 Kg a. i. /ha Mocap (13.50 cm) over untreated control (13.20 cm) $CD_{5\%}$ = 2.30 $CD_{1\%}$ = 3.10. The results of ANOVA are as follows: -

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	2114.2	117.5	61.4	1.99
Replication	2	16.90	8.5		

SE = 1.129 $CD_{5\%}$ = 2.304 $CD_{1\%}$ = 3.106

4. Effect on Root weight

The statistical analysis of the data on root weight exhibited high degree of significance by ANOVA ($F_{2, 18}$ = 12.60). The maximum growth was recorded at 4 Kg a. i. /ha dosage by different nematicides in the following sequence:-

4 Kg a.i./ha Aldicarb (12.10 g) > 4 Kg a.i./ha Fensulphothion and Carbofuran (11.20 g) < 4 Kg a.i./ha Phorate (9.30 g) 4 Kg a.i./ha Mocap (9.20 g) > 2Kg a.i./ha Aldicarb (8.80 g) > Fensulphothion and Carbofuran (8.40 g).

On the contrary, the least effective nematicides were 1Kg a.i./ha Acephate (5.10 g) < 1 Kg a.i./ha Phorate and Mocap (6.00 g) on the basis of $CD_{5\%}$ = 1.70 $CD_{1\%}$ = 2.29. The results of ANOVA are as follows:-

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	238.72	13.26	12.67	1.99
Replication	2	6.79	3.39		

SE = 0.835 $CD_{5\%}$ = 1.70 $CD_{1\%}$ = 2.29

5. Effect on Number of Leaves

The data on number of leaves of experimental plants revealed that 4Kg a.i./ha dosage showed maximum number of leaves ($F_{2,18}$ = 12.98). The order of effectiveness of different dosage of nematicides was Fensulphothion (6.00) > Carbofuran and Aldicarb (5.00) > Mocap (4.33). The least effective doses were 1Kg a. i./ha of all the nematicides (2.00) over untreated control (2.00) except 1 Kg a.i./ha Aldicarb & Fensuphothion (3.00) on the basis of $CD_{5\%}$ = 0.96 $CD_{1\%}$ = 1.29. The results of ANOVA are as follows: -

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	77.89	4.32	12.98	1.99
Replication	2	24	12		

SE = 0.471 $CD_{5\%}$ = 0961 $CD_{1\%}$ = 1.29

6. Effect on the Number of Fruits

The results of ANOVA pertaining to the number of fruits revealed that 4Kg a.i./ha dose was highly effective to increase the number of fruits. The order of their efficacy was-

Aldicarb (7.00) > Fensulphothion (5.66) > Carbofuran and 2Kg a.i./ha Aldicarb (5.00).

All the nematicides at their 1Kg a.i./ha dosage (1.00) were ineffective, except 1Kg a.i./ha Aldicarb (3.00) over untreated control (1.00) ($CD_{5\%}$ = 1.24 $CD_{1\%}$ = 1.67). The results of ANOVA follow:-

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	174.03	9.66	17.34	1.99
Replication	2	19.26	9.63		

SE = 0.609 $CD_{5\%}$ = 1.24 $CD_{1\%}$ = 1.67

7. Effect on Weight of Fruits

The statistical analysis of data on weight of fruits yielded highly significant ($F_{2,18}$ = 25.54) results which showed that 4 Kg a.i./ha dose was highly effective to increase fruit weight. The sequence of effectiveness was-

4Kg a.i./ha Aldicarb (38.40 g) > 4 Kg a.i./ha Fensulphothion (28.80 g) > 2 Kg a.i./ha Aldicarb (27.90 g) > 4 Kg a.i./ha Carbofuran (27.10 g).

All the nematicides were non effective @ 1Kg a.i./ha dosage **i.e.** 1Kg a.i./ha Fensulphothion (5.90 g) < 1Kg a.i./ha Acephate and 1Kg a.i./ha Phorate (6.10 g) over untreated control (5.90 g) ($CD_{5\%}$ = 5.45 $CD_{1\%}$ = 7.34). The results of ANOVA are as follows:-

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	4924.9	273.60	25.54	1.99
Replication	2	56.44	28.22		

SE = 2.67 $CD_{5\%}$ = 5.45 $CD_{1\%}$ = 7.34

8. Effect on Number of Galls

The statistical evaluation of the data on number of galls by ANOVA ($F_{2,18}$ = 39.28) exhibited high degree of significance. The maximum reduction in the number of galls were recorded at 4Kg a.i./ha dosage of different nematicides in the following sequence:-

Aldicarb and Carbofuran (4.00) < Fensulphothion (5.00) < Mocap (5.33) < Phorate (6.00).

The least effective doses were 1 Kg a.i./ha Acephate (98.00) > 1% Phorate (79.00) > 1% Carbofuran (72.00) over untreated control (200.00). But all the treatments were significant and superior to control root-knot galls in the root of experimental plants. The results of ANOVA are presented below.

Source	Df	SS	MSS	F Cal	$F_{5\%}$
Treatment	18	120875.9	6715.3	39.28	1.99
Replication	2	1453.29	726.64		

SE = 10.67 $CD_{5\%}$ = 21.77 $CD_{1\%}$ = 29.35

9. Effect of Number of J_2 In 1ml Soil

The data on number of J_2 in soil after statistical analysis revealed high degree of significance by ANOVA ($F_{2,18}$ = 31.32). The maximum reduction in larval density was recorded at 4 Kg a.i./ha dosage of different nematicides. The order of their efficacy was Aldicarb and Fensulphothion (2.00) < Carbofuran (2.33) < Mocap and Phorate (3.00) < Acephate (4.00). The least effective doses were 1Kg a.i./ha Acephate (22.00) > 1Kg a.i./ha Phorate (20.00) > 1 Kg a.i./ha Mocap (19.00) over untreated control (22.00). But all the dosage were highly

effective. The results of ANOVA have been discussed below.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	2613.57	145.198	31.32	1.99
Replication	2	3.82	1.91		

SE = 1.75 $CD_{5\%}$ = 3.58 $CD_{1\%}$ = 4.83

Effect of Nematicides Used as Post-inoculation Soil Treatment against *M. incognita* Two Week After Germination of Seeds of *A. esculentus*

In this experiment nematicides were used in post-inoculation soil treatment mode, two weeks post-germination at three different dosages (1, 2 and 4Kg a.i./ha). The treatment effects are dealt with separately as under.

A. Effect of Fensulphothion

1. Effect on Shoot Length

The regression line pattern exhibited no wide variations in three replicates R_1, R_2 and R_3 of ***A. esculentus*** involving application of Fensulphothion. However, maximum growth in shoot length was observed at 4Kg a.i./ha dosage in R_1 replicate, while minimum growth occurred at 1Kg a.i./ha in R_3 replicates. All the dosages of Fensulphothion were reportedly effective, because lowest growth occurred in the plants that were not treated by nematicides ($P < 0.10$) [Fig. 127, Table 17].

2. Effect on Shoot Weight

The shoot weight of experimental plants exhibited maximum growth at 4Kg a.i./ha in all the replicates R_1, R_2 and R_3. The resultant effects in all of these 3 were almost at par with each other. 1Kg a.i./ha dosage showed no effect on the growth of shoot weight. A nominal degree of declining influence was noticed in R_1 and R_2 replicates at 1Kg/h in comparison to untreated controls, but thereafter uniform increase was observed at higher doses in all the replicates. The growth pattern, however, was significant ($P < 0.10$ – $P < 0.20$) [Fig. 128, Table 17].

3. Effect on Root Length and Weight

There were no wide variations observed in the regression line patterns of R_1, R_2 and R_3 replicates of experimental plants, with maximum growth in root length [Fig. 129] and weight [Fig. 130] observed at 4Kg a.i./ha dosage. Minimum growth at 1 Kg a.i./ha dosage was observed in all the replicates. The results in all the replicates were at par with each other at different dosages of Fensulphothion ($P < 0.10$) [Table 17].

4. Effect on Number of Leaves

The effect of Fensulphothion on different replicates of ***A. esculentus*** showed that R_1 and R_2 replicates had induced inclining influence on the leaf number characteristics with increasing dosages of nematicides, while no positive association was observed in R_3 replicates, at 1Kg a. i. /ha dosage. Thereafter sharp increase was observed at higher dosages (2 and 4Kg a.i./ha) [Fig. 131, Table 17].

5. Effect on Number of Fruits

The number of fruits were maximum at 4 Kg a.i./ha in R_1 and R_3 replicates. The resultant effect of minimum growth at 1Kg a.i./ha. dosage in all the replicates was at par with each other. This indicated that 1Kg a.i./ha had no effect over the number of fruits in untreated control ($P < 0.10$) [Fig. 132, Table 17].

6. Effect on Weight of Fruits

The regression trends exhibited no variation among R_1, R_2 and R_3 replicates with maximum growth at

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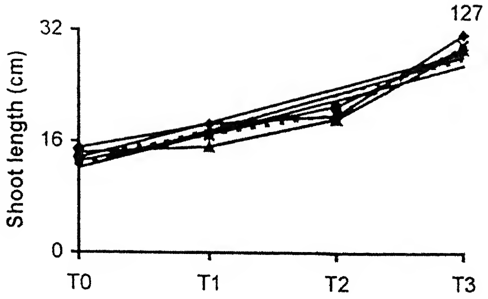

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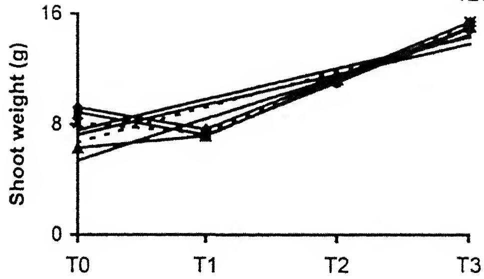

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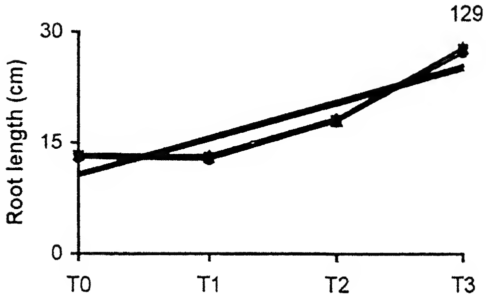

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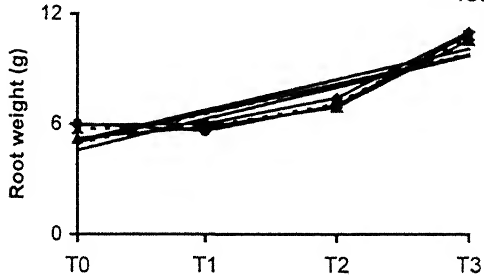

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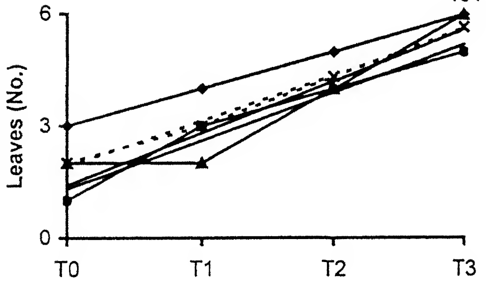

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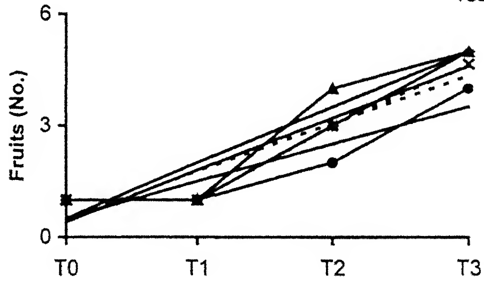

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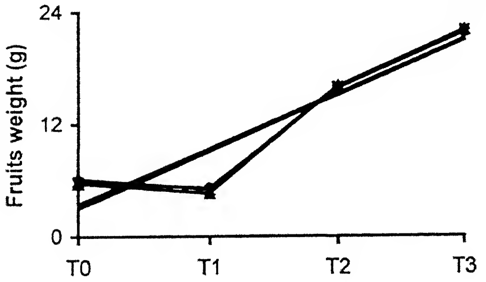

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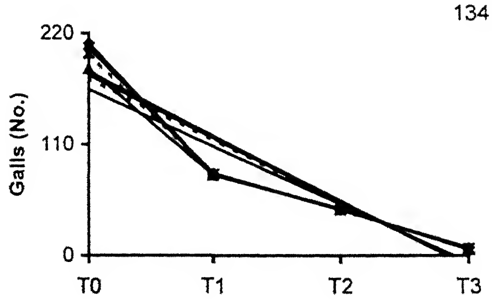

4 a. i. /h and minimum growth at 1Kg a. i. /ha in all of these. The growth pattern was highly significant ($P < 0.10$) [Fig.133, Table 17]. The weight of fruits noticeably increased after application of 2 Kg a. i./ha dosage and thereafter, steady growth was observed at 4 Kg a.i./ha dosage.

7. Effect on Number of Galls

The number of galls suddenly decreased at 1Kg a.i./ha dosage with maximum reduction at 4 Kg a.i./ha in all the replicates R_1, R_2 and R_3 of ($P < 0.20$) [Fig. 134, Table 17].

8. Effect on Number of J_2 in 1ml Soil

The dosage of 1 Kg a.i./ha was not effective in R_1 and R_2 replicates because the density of J_2 in soil was similar to that found in the soil around untreated plant untreated plants. But there was sudden decline in the number of J_2 at 2 Kg a.i./ha dosage in R_1, R_2 and R_3 replicates. The effective influence of 2 and 4 Kg a.i./ha dosages was identical ($P < 0.20$ - $P < 0.10$) [Fig. 135, Table 17].

Table 17 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after post-inoculation soil treatment, two week after germination of plants by Fensulphothion (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 14.04 + 4.10 X	r = 0.729	$P < 0.100^S$
	R_2	Y = 12.91 4.17 X	r = 0.749	$P < 0.100^S$
	R_3	Y = 12.71 + 3.85 X	r = 0.731	$P < 0.100^S$
	Mean	Y = 13.22 + 4.04 X	r = 0.742	$P < 0.100^S$
Shoot weight	R_1	Y = 7.76 + 1.79 X	r = 0.679	$P < 0.200^S$
	R_2	Y = 7.41 + 1.75 X	r = 0.676	$P < 0.200^S$
	R_3	Y = 3.83 + 2.31 X	r = 0.735	$P < 0.100^S$
	Mean	Y = 7 + 1.95 X	r = 0.707	$P < 0.100^S$
Root length	R_1	Y = 11 42 + 3.93 X	r = 0.724	$P < 0.100^S$
	R_2	Y = 10 92 + 3.88 X	r = 0.723	$P < 0.100^S$
	R_3	Y = 11.17 + 3.95 X	r = 0.720	$P < 0.100^S$
	Mean	Y = 11.17 + 3.92 X	r = 0.722	$P < 0.100^S$
Root weight	R_1	Y = 5.22 + 1.34 X	r = 0.723	$P < 0.100^S$
	R_2	Y = 5.07 + 1.31 X	r = 0.699	$P < 0.100^S$
	R_3	Y = 4.71 + 1.37 X	r = 0.733	$P < 0.100^S$
	Mean	Y = 5 + 1.34 X	r = 0.720	$P < 0.100^S$
Leaves (No.)	R_1	Y = 3.2 + 0.742 X	r = 0.737	$P < 0.100^S$
	R_2	Y = 1.6 + 0.942 X	r = 0.707	$P < 0.100^S$
	R_3	Y = 1.6 + 1.08 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 2.13 + 0.922 X	r = 0.741	$P < 0.100^S$
Fruits (No)	R_1	Y = 0 599 + 1.08 X	r = 0.726	$P < 0.100^S$
	R_2	Y = 0.6 + 0.8 X	r = 0.724	$P < 0.100^S$
	R_3	Y = 0.8 + 1.11 X	r = 0.692	$P < 0.100^S$
	Mean	Y = 0.668 + 0.99 X	r = 0.722	$P < 0.100^S$
Fruit weight	R_1	Y = 4.43 + 4.53 X	r = 0.702	$P < 0.100^S$
	R_2	Y = 4.27 + 4.50 X	r = 0.707	$P < 0.100^S$
	R_3	Y = 3.960 + 4.64 X	r = 0.701	$P < 0.100^S$
	Mean	Y = 4.22 + 4.56 X	r = 0.703	$P < 0.100^S$
Galls (No.)	R_1	Y = 165.8 – 45 6 X	r = -0.664	$P < 0.200^S$
	R_2	Y = 162.4 – 44.8 X	r = -0.667	$P < 0.200^S$
	R_3	Y = 150.6 – 40.9 X	r = -0.683	$P < 0.200^S$
	Mean	Y = 159.6 – 43.7 X	r = -0.671	$P < 0.200^S$
J2 in 1ml soil (No.)	R_1	Y = 21.8 – 5.17 X	r = -0.687	$P < 0.200^S$
	R_2	Y = 21.4 – 4.8 X	r = -0.662	$P < 0.200^S$
	R_3	Y = 21 – 4.5 X	r = -0.690	$P < 0.100^S$
	Mean	Y = 20.2 – 4.57 X	r = -0.684	$P < 0.200^S$

B. Effect of Carbofuran

1. Effect on Shoot Length and Weight

All the dosages of Carbofuran were effective to increase shoot length [Fig. 136] and weight [Fig. 137], because minimum growth was observed in plants that were not treated with nematicides. The maximum growth occurred at 4 Kg a.i./ha dosage in all the replicates R_1, R_2 and R_3. The influence in all the replicates was at par with each other at all the dosages ($P < 0.10$) [Fig. 136, Table 18].

2. Effect on Root Length and Weight

The gradually increasing effect of nematicides on root length in different replicates was observed. The optimally effective influence was encountered in 4 Kg a.i./ha dosage, while 1 Kg a.i./ha recorded minimal influence. However, the steep increase in root weight at 2 and 4 Kg a.i./ha was distinctly noticed ($P < 0.10$) [Fig. 138-139, Table 18].

3. Effect on Number of Leaves and Fruits

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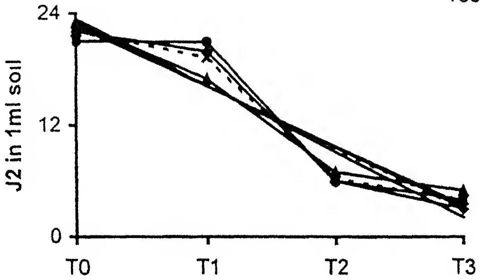

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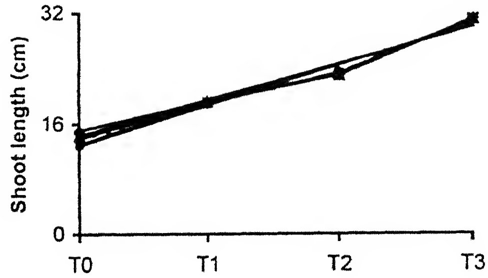

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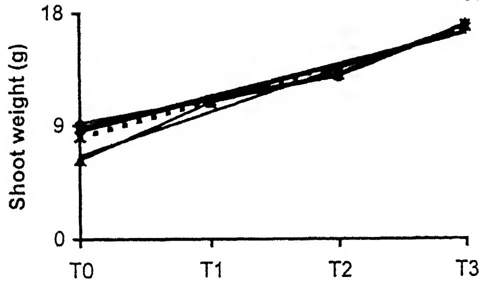

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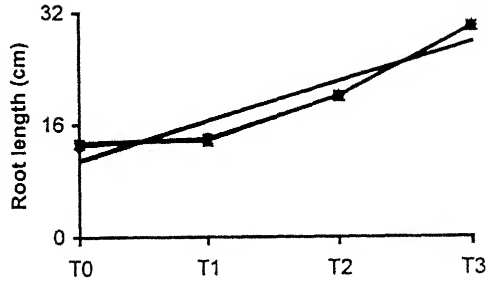

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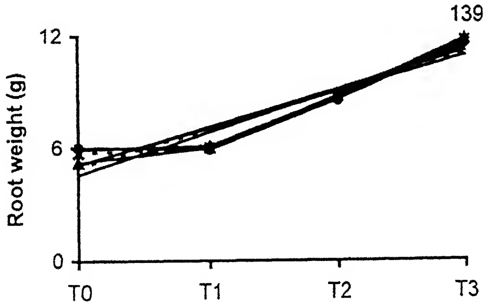

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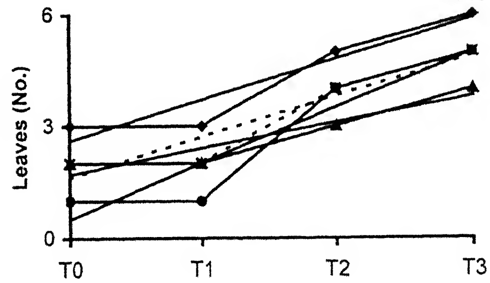

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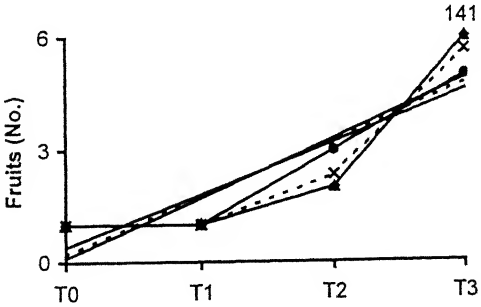

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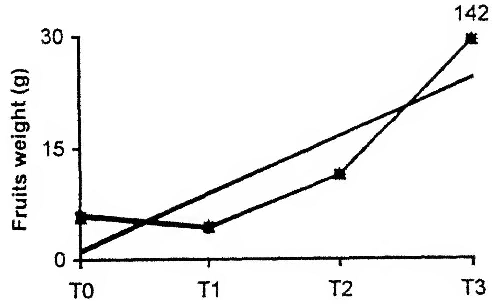


No change was observed at 1Kg a.i./ha treatment but the rise was steep in number of leaves and fruits in all the replicates at higher dosage. The linear regression trends thus exhibited a significant positive correlation of soil treatment by Carbofuran with the number of leaves and fruits of ***A. esculentus*** [Figs. 140, 141 Table 18], but the efficacy was best represented in R_3 replicates in comparison to R_1 and R_2, respectively, in that order.

4. Effect on Fruits Weight

There was wide variation observed in efficacy of different dosages of Carbofuran on all the three replicates R_1, R_2 and R_3 of ***A. esculentus***. The maximum weight of fruits was observed at 4 Kg a.i./ha dosage and minimum at 1Kg a.i./ha in all the replicates. ($P < 0.10$) [Fig. 142, Table 18].

5. Effect on Number of Galls

The sudden reduction occurred in the number of galls in experimental plants where soil was initially 1st treated with 1Kg a.i./ha Carbofuran. The effect of

Table 18 : Linear regression trends depicting variations in *A. esculentus* characteristics infesting *M. incognita* after post-inoculation soil treatment, two week after germination of plants by Carbofuran (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 15.06 + 4.00 X	r = 0.749	$P < 0.100^S$
	R_2	Y = 1.84 + 4.40 X	r = 0.745	$P < 0.100^S$
	R_3	Y = 14.66 + 4.10 X	r = 0.749	$P < 0.100^S$
	Mean	Y = 14.52 + 4.17 X	r = 0.748	$P < 0.100^S$
Shoot weight	R_1	Y = 9.16 + 2.00 X	r = 0.749	$P < 0.100^S$
	R_2	Y = 8.91 + 2.03 X	r = 0.749	$P < 0.100^S$
	R_3	Y = 7.31 + 2.58 X	r = 0.732	$P < 0.100^S$
	Mean	Y = 8.46 + 2.20 X	r = 0.747	$P < 0.100^S$
Root length	R_1	Y = 11.65 + 4.42 X	r = 0.733	$P < 0.100^S$
	R_2	Y = 11.36 + 4.48 X	r = 0.737	$P < 0.100^S$
	R_3	Y = 11.43 + 4.45 X	r = 0.730	$P < 0.100^S$
	Mean	Y = 11.48 + 4.45 X	r = 0.733	$P < 0.100^S$
Root weight	R_1	Y = 5.37 + 1.58 X	r = 0.732	$P < 0.100^S$
	R_2	Y = 5.35 + 1.52 X	r = 0.725	$P < 0.100^S$
	R_3	Y = 4.91 + 1.74 X	r = 0.740	$P < 0.100^S$
	Mean	Y = 5.21 + 1.61 X	r = 0.734	$P < 0.100^S$
Leaves (No.)	R_1	Y = 2.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 0.8 + 1.11 X	r = 0.692	$P < 0.100^S$
	R_3	Y = 1.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 1.8 + 0.828 X	r = 0.707	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.199 + 1.31 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 0.599 + 1.08 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 0.199 + 1.31 X	r = 0.707	$P < 0.100^S$
	Mean	Y = 0.334 + 1.23 X	r = 0.719	$P < 0.100^S$
Fruit weights	R_1	Y = 1.79 + 6.27 X	r = 0.702	$P < 0.100^S$
	R_2	Y = 1.45 + 6.36 X	r = 0.705	$P < 0.100^S$
	R_3	Y = 1.52 + 6.37 X	r = 0.708	$P < 0.100^S$
	Mean	Y = 1.6 + 6.32 X	r = 0.705	$P < 0.100^S$
Galls (No.)	R_1	Y = 162.4 – 46.3 X	r = -0.655	$P < 0.200^S$
	R_2	Y = 159 – 45.5 X	r = -0.657	$P < 0.200^S$
	R_3	Y = 147.2 – 41.2 X	r = -0.669	$P < 0.200^S$
	Mean	Y = 156.2 – 44.4 X	r = -0.660	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 22.2 – 4.97 X	r = -0.735	$P < 0.100^S$
	R_2	Y = 21.2 – 4.8 X	r = -0.748	$P < 0.100^S$
	R_3	Y = 22 – 4.8 X	r = -0.724	$P < 0.100^S$
	Mean	Y = 21.8 – 4.88 X	r = -0.739	$P < 0.100^S$

nematicides thereafter stabilized at higher dosages of 2 and 4 Kg a.i./ha soil ($P < 0.20$) [Fig. 143, Table 18], till the number of galls touched nadir at the highest dosage of 4 Kg a.i./ha.

6. Effect on number of J_2 In 1ml Soil

The number of second stage juveniles (J_2) in the soil of experimental plants were highly reduced at 4 Kg a.i./ha in R_2 replicates, while at 1Kg a.i./ha dosage the decline in number of J_2 was minimum in R_1 replicate ($P < 0.10$) [Fig. 144, Table 18]. The decline in J_2 stage larvae in the soil of potted plants containing Carbofuran treated soil was gradual with the increased concentration of nematicides from 2 Kg to 4Kg a.i./ha.

C. Effect of Mocap

1. Effect on Shoot Length and Weight

The quantum gain in the length of shoot [Fig. 145] and shoot weight [Fig. 146] declined slightly at 1 Kg a.i./ha dosage in all the replicates R_1, R_2 and R_3 of ***A. esculentus***. The increasing effect of nematicides

application was recorded at higher dosages i.e. 2 and 4Kg a.i./ha with peak being attained at 4Kg a.i./ha dosage ($P < 0.10$) [Table 19].

2. Effect on Root Length and Weight

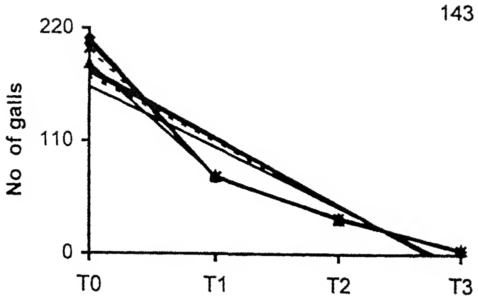
The change in root length [Fig. 147] and weight [Fig. 148] was not substantial at 1Kg a.i./ha dosage in R_1, R_2 and R_3 replicates. On the contrary, consistently increasing influence on length of root was observed at higher dosage i.e. 2 and 4Kg a.i./ha dosage. The regression line patterns were found statistically significant ($P < 0.20$ - $P < 0.10$) [Fig. 147, Table 19]. The gain in weight of root was, however, not substantially equal to that of length of root [Fig. 148]. While the weight gain in root tissues was gradual with peak at the application of 4 Kg a.i./ha in R_2 and R_3 replicates, the increase in weight gain was substantively higher in R_1 replicates when 2 Kg a.i./ha was applied than at the application of 4Kg a.i./ha dosage [Fig.148, Table 19].

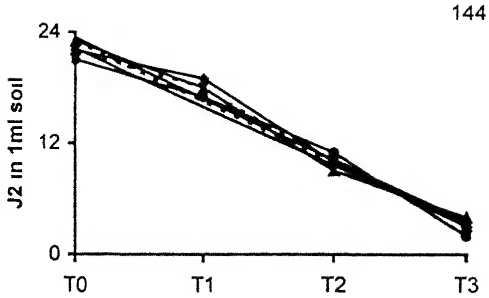
3. Effect on Number of Leaves and Fruits

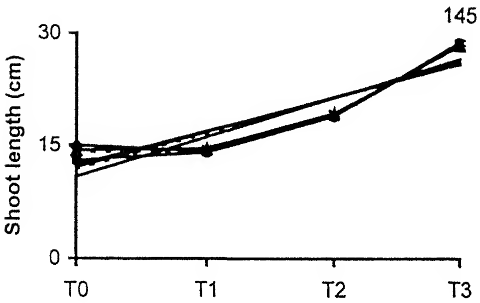
The maximum number of leaves and fruits were observed at 4Kg a.i./ha dosage in R_1 replicates while minimum number of leaves and fruits were achieved at 1 Kg a.i./ha dosage in R_2 replicates. The distinguishing feature of the experiment was that nematicides exhibited no influence on the number of leaves at 1 Kg a.i./ha dosage [Fig. 149] in R_1 and R_2 replicates, and in the number of fruits [Fig. 150]. But 2 Kg a.i./ha dosage showed marked impact to increase the number of leaves, while the number of fruits increased at 2 Kg a.i./ha dosage with the peak attained at 4 Kg a.i./ha dosage ($P < 0.20 - P < 010$) [Figs. 149, 150, Table 19].

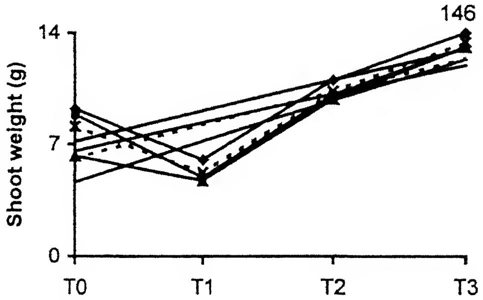
4. Effect on Weight of Fruits

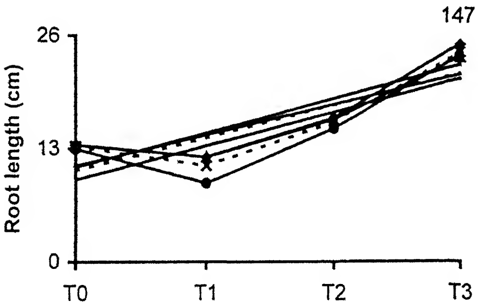
The maximum incentive in weight of fruits was exhibited at 4 Kg a.i./ha dosage in R_1 replicates while minimum at 1Kg a.i./ha dosage in all the replicates. The weight of fruits increased sharply at 2 Kg a.i./ha in all the replicates ($P < 0.20$) [Fig. 151, Table 19], and thereafter growth was steady at 4Kg a.i./ha dosage.

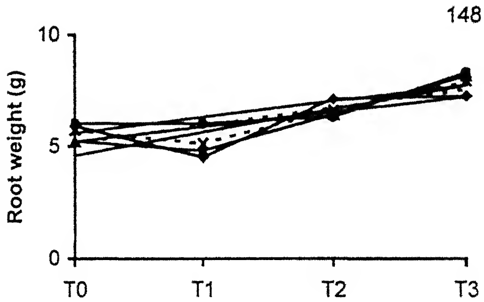

143
220
110
0
No of galls
T0
T1
T2
T3

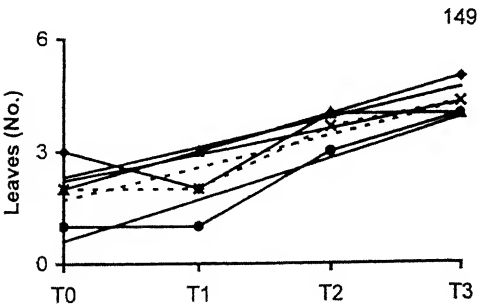

144
24
12
0
J2 in 1ml soil
T0
T1
T2
T3


145
30
15
0
Shoot length (cm)
T0
T1
T2
T3


146
14
7
0
Shoot weight (g)
T0
T1
T2
T3


147
26
13
0
Root length (cm)
T0
T1
T2
T3


148
10
5
0
Root weight (g)
T0
T1
T2
T3


149
6
3
0
Leaves (No.)
T0
T1
T2
T3

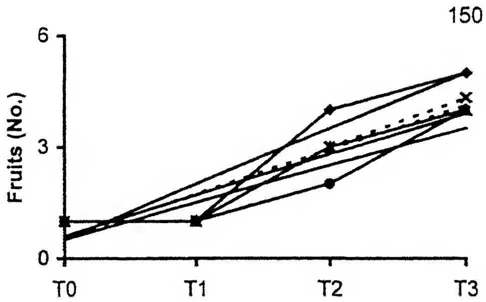

150
6
3
0
Fruits (No.)
T0
T1
T2
T3

Table 19 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after post-inoculation soil treatment, two week after germination of plants by Mocap (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 12.76 + 3.68 X	r = 0.713	$P < 0.100^S$
	R_2	Y = 11.43 + 4.19 X	r = 0.735	$P < 0.100^S$
	R_3	Y = 12.59 + 3.77 X	r = 0.728	$P < 0.100^S$
	Mean	Y = 12.66 + 3.88 X	r = 0.727	$P < 0.100^S$
Shoot weight	R_1	Y = 7.32 + 1.56 X	r = 0.596	$P < 0.200^S$
	R_2	Y = 6.67 + 1.46 X	r = 0.553	$P < 0.200^S$
	R_3	Y = 4.97 + 1.99 X	r = 0.680	$P < 0.200^S$
	Mean	Y = 6.32 + 1.67 X	r = 0.618	$P < 0.200^S$
Root length	R_1	Y = 11.14 + 3.19 X	r = 0.701	$P < 0.100^S$
	R_2	Y = 9.64 + 3.19 X	r = 0.655	$P < 0.200^S$
	R_3	Y = 11.32 + 2.83 X	r = 0.702	$P < 0.100^S$
	Mean	Y = 10.7 + 3.07 X	r = 0.686	$P < 0.200^S$
Root weight	R_1	Y = 5.31 + 0.501 X	r = 0.502	$P < 0.200^S$
	R_2	Y = 5.6 + 0.600 X	r = 0.692	$P < 0.200^S$
	R_3	Y = 4.69 + 0.827 X	r = 0.704	$P < 0.100^S$
	Mean	Y = 5.2 + 0.642 X	r = 0.676	$P < 0.200^S$
Leaves (No.)	R_1	Y = 2.4 + 0.62 X	r = 0.623	$P < 0.200^S$
	R_2	Y = 0.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	R_3	Y = 2.4 + 0.48 X	r = 0.649	$P < 0.200^S$
	Mean	Y = 1.86 + 0.646 X	r = 0.699	$P < 0.100^S$
Fruits (No.)	R_1	Y = 0.80 + 1.11 X	r = 0.692	$P < 0.100^S$
	R_2	Y = 0.6 + 0.8 X	r = 0.724	$P < 0.100^S$
	R_3	Y = 0.8 + 0.82 X	r = 0.707	$P < 0.100^S$
	Mean	Y = 0.734 + 0.913 X	r = 0.717	$P < 0.100^S$
Fruit weights	R_1	Y = 4.26 + 4.58 X	r = 0.679	$P < 0.200^S$
	R_2	Y = 3.7 + 4.44 X	r = 0.675	$P < 0.200^S$
	R_3	Y = 3.98 + 4.38 X	r = 0.682	$P < 0.200^S$
	Mean	Y = 3.98 + 4.46 X	r = 0.679	$P < 0.200^S$
Galls (No.)	R_1	Y = 177.8 – 45.4 X	r = -0.695	$P < 0.100^S$
	R_2	Y = 174 – 44.28 X	r = -0.699	$P < 0.100^S$
	R_3	Y = 161.8 – 40.45 X	r = -0.713	$P < 0.100^S$
	Mean	Y = 171.2 – 43.4 X	r = -0.702	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 23.2 – 5.11 X	r = -0.728	$P < 0.100^S$
	R_2	Y = 21.6 – 4.3 X	r = -0.714	$P < 0.100^S$
	R_3	Y = 23.6 – 4.7 X	r = -0.747	$P < 0.100^S$
	Mean	Y = 22.8 – 4.74 X	r = -0.738	$P < 0.100^S$

5. Effect on Number of Galls and J_2 Larvae

The statistically significant decline in the number of galls as well as J_2 larvae in soil around ***A. esculentus*** occurred at 4Kg a.i./ha dosage. But the decline in the number of galls was uniform from 1 to 4 Kg a.i./ha in all the replicates. ($P < 0.20 - P < 0.10$) [Figs. 152, 153, Table 19].

D. Effect of Phorate

1. Effect on Shoot Length

The maximum growth in shoot length was observed at 4Kg a.i./ha dosage in R_3 replicates while minimum growth was observed at 1 Kg a.i./ha dosage in R_2 and R_3 replicates ($P < 0.1$) [Fig. 154, Table 20].

2. Effect on Shoot Weight

The maximum growth in weight of shoot was observed at 4 Kg a.i./ha in R_1 replicates while the growth decline resulted at 1Kg a.i./ha in all the replicates than control. ($P < 0.20$) [Fig. 155, Table 20].

3. Effect on Root Length and weight

The growth pattern of root length was similar to shoot length and weight shown in the preceding lines. The

maximum growth eas encountered at 4Kg a.i./ha in all the replicates, while minimum growth in root length was achieved at 1Kg a.i./ha [Fig. 156] dosage in R_1 replicates. The minimum growth in root weight was observed at 1Kg a.i./ha dosage in R2 replicates. ($P < 0.20$ - $P < 0.10$) [Fig. 157, Table 20].

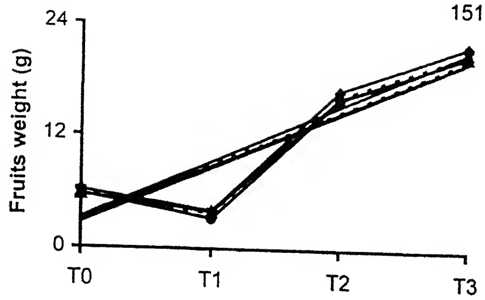
4. Effect on Number of Leaves

The maximum number of leaves was observed at 4 Kg a.i./ha in R_1 replicates while minimum number of leaves was recorded at 1 Kg a.i./ha in R_2 replicates. The number of leaves did increase at 1 Kg a.i./ha. Thereafter, steady increase occurred at 2Kg a.i./ha dosage while at 4Kg a.i./ha dosage the results were at par with 2 Kg a.i./ha dosage in all the replicates. ($P < 0.20$) [Fig. 158, Table 20].

5. Effect on Number of Fruits

There was no increase in the number of fruits at 1Kg a.i./ha dosage of Phorate in all the replicates of experimental plants. But at 2Kg a.i./ha dosage drastic increased in the number of fruits was observed in R_3

151



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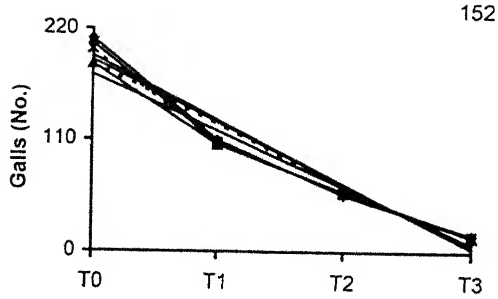

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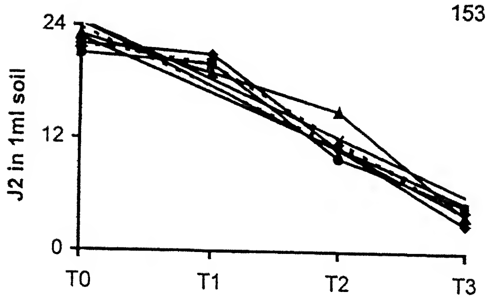

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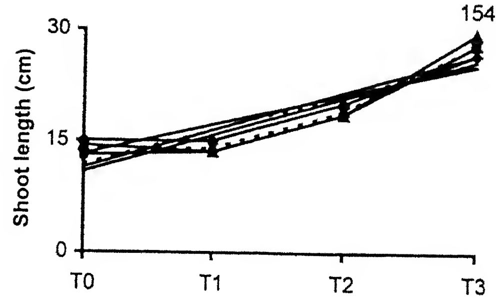

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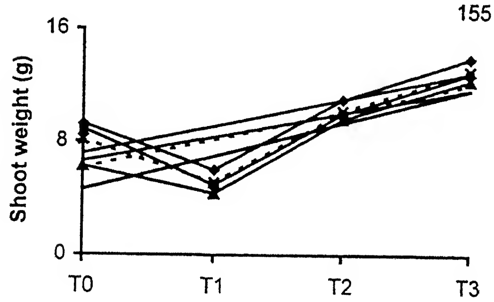

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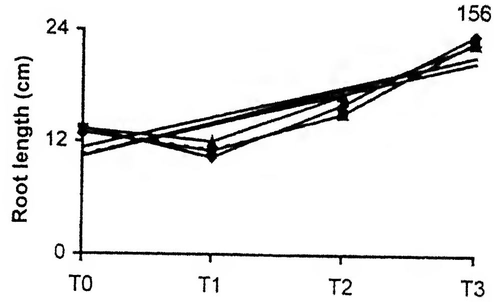

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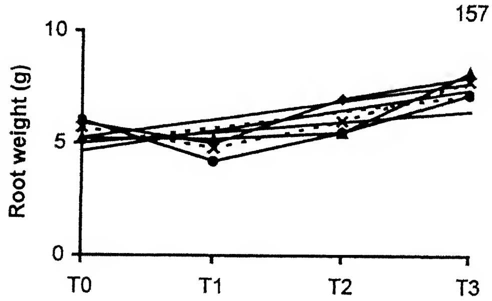
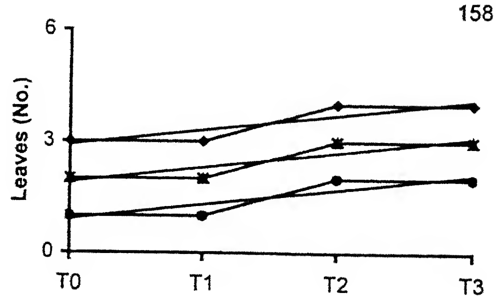


158



replicates, and maximum number of fruits were recorded at 4Kg a.i./ha in R_2 and R_3 replicates. The regression line patterns exhibited significantly ($P < 0.10$) increasing trend [Fig. 159, Table 20].

6. Effect on Weight of Fruits

The 1 Kg a.i./ha dosage of Phorate did not increase weight of fruits in R_1, R_2 and R_3 replicates. But this increase was noticeable at 2 Kg a.i./ha in R_2 and R_3 replicates. But R_1 replicates exhibited steep rise in the weight of fruits by the application of 4 Kg a.i./ha dosage of Phorate. ($P < 0.20$ – $P < 0.10$) [Fig. 160, Table 20].

7. Effect on Number of Galls

The maximum reduction in the number of galls on the root of ***A. esculentus*** were observed at 4 Kg a.i./ha in R_1, R_2 and R_3 replicates in comparison to 2 and 4 Kg a.i./ha doses. The decline in the number of galls was uniform and steep at all dosage of nematicides ($P < 0.20$ – $P < 0.10$) [Fig. 161, Table 20].

8. Effect on Number of J_2 in 1ml Soil

The density of second stage juveniles was highly reduced at 4 Kg a.i./ha in R_2 replicates, while at 1 Kg a.i./ha, no reduction in the number of J_2 was observed. But at 2 Kg a.i./ha dosage sudden decline in the number of J_2 achieved ($P < 0.10 - P < 0.20$) [Fig. 162, Table 20].

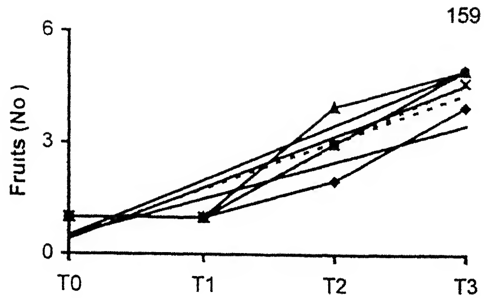
E. Effect of Aldicarb

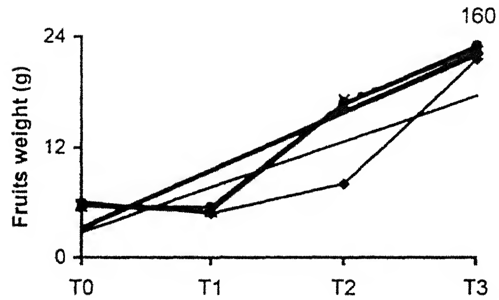
1. Effect on Shoot and Root Length and Weight

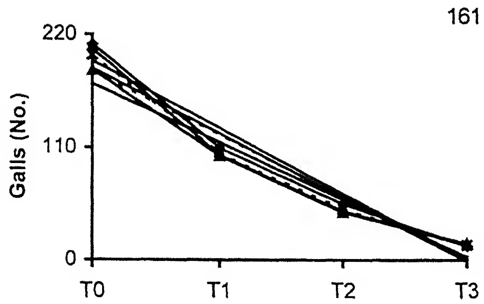
Aldicarb was highly effective at 1, 2 and 4 Kg a.i./ha doses in all the replicates, because minimum growth was recorded in plants that were not treated with nematicides. Maximum increase in shoot length and weight, and root length and weight occurred at 4 Kg a.i./ha in R_1, R_2 and R_3 replicates. The distinguishing feature was that the application of 4 Kg a.i./ha dosage influenced sharp increase in all the growth parameters in shoot and root length and weight ($P < 0.10$) [Figs. 163-166, Table 21].

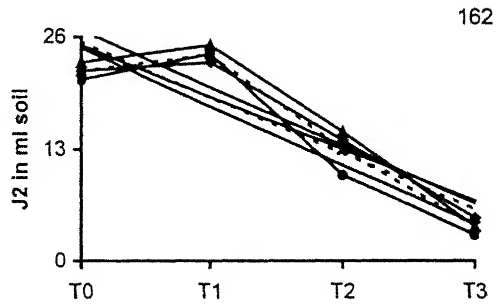
2. Effect on Number of Leaves

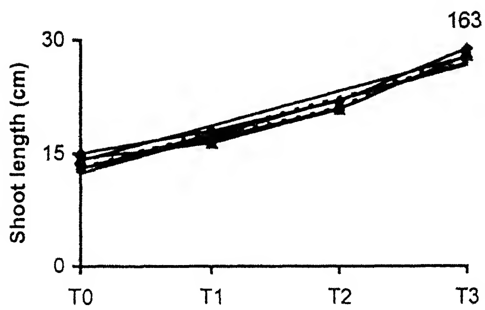
The number of leaves in the experimental plants were maximum at 2 Kg a.i./ha in R_1, while minimum at 1

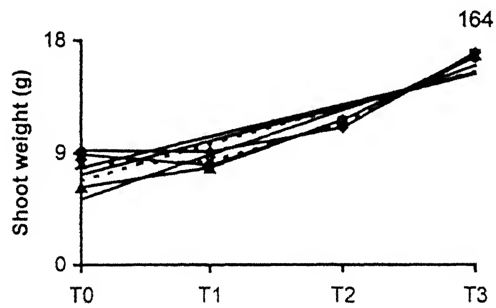

159
Fruits (No)
0
3
6
T0
T1
T2
T3

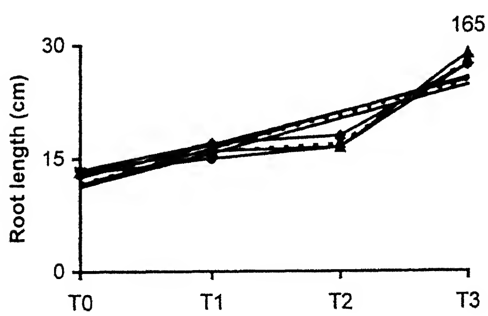

160
Fruits weight (g)
0
12
24
T0
T1
T2
T3


161
Galls (No.)
0
110
220
T0
T1
T2
T3


162
J2 in ml soil
0
13
26
T0
T1
T2
T3


163
Shoot length (cm)
0
15
30
T0
T1
T2
T3


164
Shoot weight (g)
0
9
18
T0
T1
T2
T3


165
Root length (cm)
0
15
30
T0
T1
T2
T3

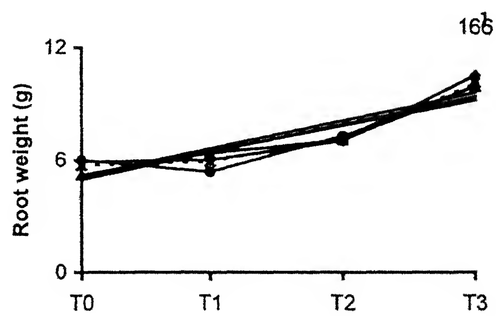

166
Root weight (g)
0
6
12
T0
T1
T2
T3

Table 20 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after post-inoculation soil treatment, two week after germination of plants by Phorate (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 13.68 + 3.12 X	r = 0.728	$P < 0.100^S$
	R_2	Y = 11.32 + 3.44 X	r = 0.731	$P < 0.100^S$
	R_3	Y = 11.78 + 4.09 X	r = 0.712	$P < 0.100^S$
	Mean	Y = 12.26 + 3.72 X	r = 0.724	$P < 0.100^S$
Shoot weight	R_1	Y = 7.32 + 1.56 X	r = 0.596	$P < 0.200^S$
	R_2	Y = 6.71 + 1.40 X	r = 0.548	$P < 0.200^S$
	R_3	Y = 4.93 + 1.80 X	r = 0.660	$P < 0.200^S$
	Mean	Y = 6.28 + 1.59 X	r = 0.609	$P < 0.200^S$
Root length	R_1	Y = 10.66 + 2.93 X	r = 0.667	$P < 0.200^S$
	R_2	Y = 10.56 + 2.79 X	r = 0.684	$P < 0.200^S$
	R_3	Y = 11.66 + 2.60 X	r = 0.703	$P < 0.100^S$
	Mean	Y = 10.76 + 2.75 X	r = 0.677	$P < 0.200^S$
Root weight	R_1	Y = 5.34 + 0.648 X	r = 0.636	$P < 0.200^S$
	R_2	Y = 4.94 + 0.44 X	r = 0.462	$P > 0.50^{NS}$
	R_3	Y = 4.66 + 0.78 X	r = 0.685	$P < 0.200^S$
	Mean	Y = 4.98 + 0.62 X	r = 0.637	$P < 0.200^S$
Leaves (No.)	R_1	Y = 3 + 0.28 X	r = 0.633	$P < 0.200^S$
	R_2	Y = 1 + 0.28 X	r = 0.633	$P < 0.200^S$
	R_3	Y = 2 + 0.285 X	r = 0.633	$P < 0.200^S$
	Mean	Y = 2 + 0.285 X	r = 0.633	$P < 0.200^S$
Fruits (No.)	R_1	Y = 0.6 + 0.8 X	r = 0.724	$P < 0.100^S$
	R_2	Y = 0.59 + 1.08 X	r = 0.726	$P > 0.100^S$
	R_3	Y = 0.8 + 1.11 X	r = 0.692	$P < 0.100^S$
	Mean	Y = 0.66 + 0.99 X	r = 0.722	$P < 0.100^S$
Fruit weights	R_1	Y = 4.88 + 4 41 X	r = 0 673	$P < 0.200^S$
	R_2	Y = 4.37 + 4.78 X	r = 0.709	$P < 0.100^S$
	R_3	Y = 4.12 + 4.76 X	r = 0.705	$P < 0.100^S$
	Mean	Y = 4.46 + 4.65 X	r = 0.697	$P < 0.100^S$
Galls (No.)	R_1	Y = 178.2 – 46.25 X	r = -0.698	$P < 0.100^S$
	R_2	Y = 170.8 – 44.6 X	r = -0.686	$P < 0.200^S$
	R_3	Y = 158 – 40.2 X	r = -0.696	$P < 0.100^S$
	Mean	Y = 169 – 43.7 X	r = -0.694	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 24.2 – 4.68 X	r = -0.717	$P < 0.100^S$
	R_2	Y = 23.6 – 5.2 X	r = -0.683	$P < 0.200^S$
	R_3	Y = 26 – 5.28 X	r = -0.710	$P < 0.100^S$
	Mean	Y = 24.6 – 5.05 X	r = -0.705	$P < 0.100^S$

Kg a.i./ha dosage in R3 replicates ($P < 0.20 - P < 0.10$) [Fig. 167, Table 21]. The number of leaves produced were equal at 2 and 4Kg a.i./ha dosage.

3. Effect on Number of Fruits

The number of fruits significantly increased with increasing dosage of Aldicarb with peak attained at 4 Kg a.i./ha in R_2 replicates. In R_3 replicate the number of fruits was slightly decreased at 4Kg a.i./ha in comparison to 2 Kg a.i./ha dosage ($P < 0.20 - P < 0.10$) [Fig. 168, Table 21].

4. Effect on Weight of Fruits

The weight of fruits increased significantly with peak attained at 4 Kg a.i./ha dosage in all the replicates. Aldicarb was effective at all the doses because minimum growth in weight of fruits was recorded in the plants that are not treated with nematicides ($P < 0.10$) [Fig. 169, Table 21].

5. Effect on Number of Galls and J_2 In 1ml Soil:

Table 21 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after post-inoculation soil treatment, two week after germination of plants by Aldicarb (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	Replicate	Linear regression trends	Correlation coefficient	Level of significance
Shoot length	R_1	Y = 14.8 + 3.54 X	r = 0.749	$P < 0.100^S$
	R_2	Y = 13.16 + 3.75 X	r = 0.749	$P < 0.100^S$
	R_3	Y = 13.71 + 3.54 X	r = 0.746	$P < 0.100^S$
	Mean	Y = 13.89 + 3.61 X	r = 0.749	$P < 0.100^S$
Shoot weight	R_1	Y = 7.96 + 2.06 X	r = 0.711	$P < 0.100^S$
	R_2	Y = 7.51 + 2.14 X	r = 0.708	$P < 0.100^S$
	R_3	Y = 5.83 + 2.73 X	r = 0.745	$P < 0.100^S$
	Mean	Y = 7.1 + 2.31 X	r = 0.730	$P < 0.100^S$
Root length	R_1	Y = 12 94 + 3.44 X	r = 0.734	$P < 0.100^S$
	R_2	Y = 11.54 + 3.67 X	r = 0.722	$P < 0.100^S$
	R_3	Y = 11.88 + 3.89 X	r = 0.712	$P < 0.100^S$
	Mean	Y = 12.12 + 3.67 X	r = 0.723	$P < 0.100^S$
Root weight	R_1	Y = 5.24 + 1.20 X	r = 0.715	$P < 0.100^S$
	R_2	Y = 5.21 + 1.09 X	r = 0.696	$P < 0.100^S$
	R_3	Y = 5.09 + 1.16 X	r = 0.744	$P < 0.100^S$
	Mean	Y = 5.18 + 1.15 X	r = 0.728	$P < 0.100^S$
Leaves (No.)	R_1	Y = 3.4 + 0.48 X	r = 0.649	$P < 0.200^S$
	R_2	Y = 1.0 + 0.68 X	r = 0.621	$P < 0.200^S$
	R_3	Y = 2 + 0.28 X	r = 0.633	$P > 0.200^S$
	Mean	Y = 2.4 + 0.485 X	r = 0.649	$P < 0.200^S$
Fruits (No.)	R_1	Y = 1.2 + 1.02 X	r = 0.721	$P < 0.100^S$
	R_2	Y = 1 + 1.28 X	r = 0.742	$P < 0.100^S$
	R_3	Y = 2 + 0.71 X	r = 0.535	$P < 0.200^S$
	Mean	Y = 1.34 + 1.0 X	r = 0.704	$P < 0.100^S$
Fruit weights	R_1	Y = 7.26 + 5.58 X	r = 0.727	$P < 0.100^S$
	R_2	Y = 6.89 + 5.75 X	r = 0.722	$P < 0.100^S$
	R_3	Y = 6.79 + 5.88 X	r = 0.729	$P < 0.100^S$
	Mean	Y = 6.98 + 5.74 X	r = 0.726	$P < 0.100^S$
Galls (No.)	R_1	Y = 153.6 – 45.2 X	r = -0.621	$P < 0.200^S$
	R_2	Y = 149.6 – 43.6 X	r = -0.618	$P < 0.200^S$
	R_3	Y = 138.4 – 39.6 X	r = -0.631	$P < 0.200^S$
	Mean	Y = 147.2 – 42.8 X	r = -0.623	$P < 0.200^S$
J2 in 1ml soil	R_1	Y = 18.6 – 4.4 X	r = -0.685	$P < 0.200^S$
	R_2	Y = 18.8 – 4.6 X	r = -0.720	$P < 0.100^S$
	R_3	Y = 20.2 – 4.54 X	r = -0.704	$P < 0.100^S$
	Mean	Y = 19.2 – 4.54 X	r = -0.704	$P < 0.100^S$

The number of galls was highly reduced at 4 Kg a.i./ha in all the replicates R_1, R_2 and R_3, but sudden decline in the number of galls was observed in all the replicates at 1 Kg a.i./ha, and thereafter the reduction in galls number steadied with attainment of uniform density of J_2 larvae ($P < 0.20$) [Figs. 170, 171 Table 21].

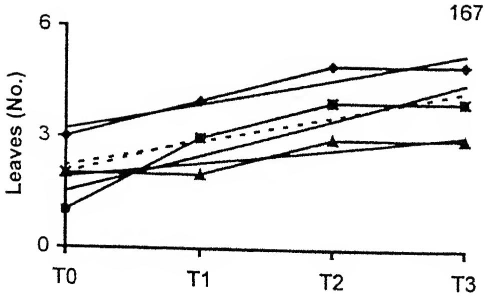
F. Effect of Acephate

1. Effect on Shoot and Root Length and Weight

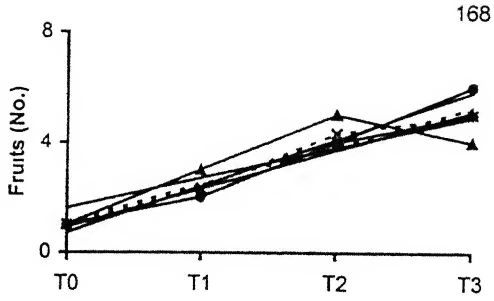
The change in shoot length, root length and root weight was not substantial in R_1, R_2 and R_3 replicates of experimental plants after soil treatment by 1Kg / ha dosage of Acephate. The shoot weight slightly declined at 1 Kg a.i./ha dosage than untreated plants. On the contrary, consistently inclining influence on shoot length [Fig. 172], shoot weight [Fig. 173], root length [Fig. 174] and root weight [Fig. 175] were observed at 2 and 4 Kg a.i./ha dosages in all the replicates. The regression line patterns were, however, significant ($P < 0.20$ - $P < 0.10$) [Figs. 172-175, Table 22].

2. Effect on the Number of Leaves

167



168



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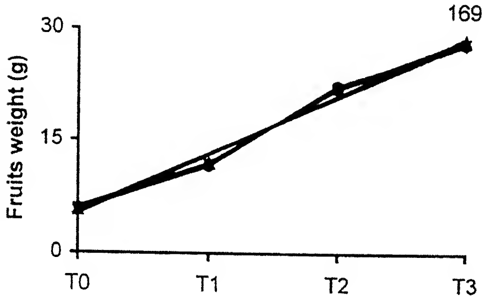

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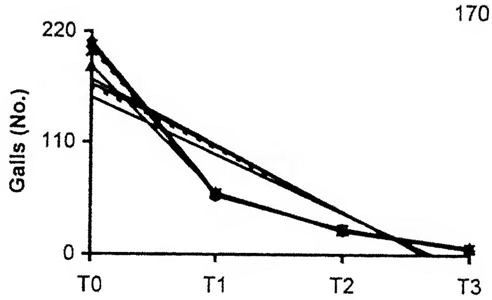

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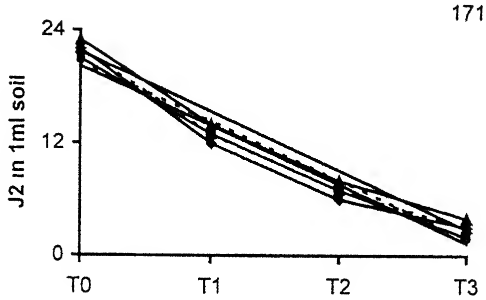
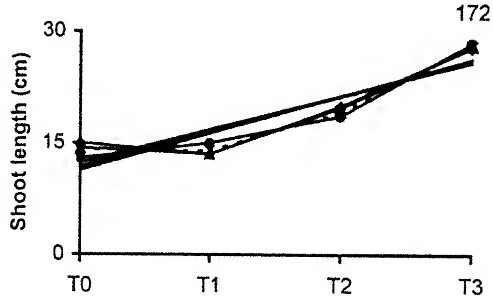
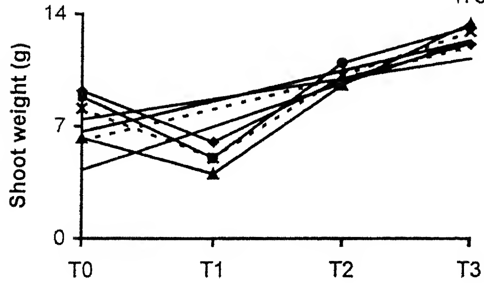


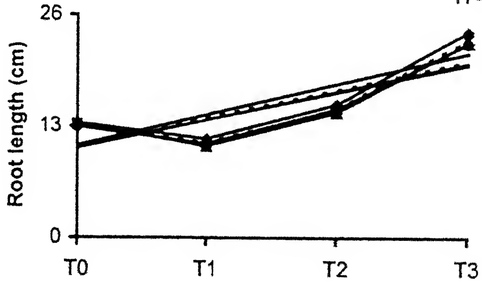
172



173



174



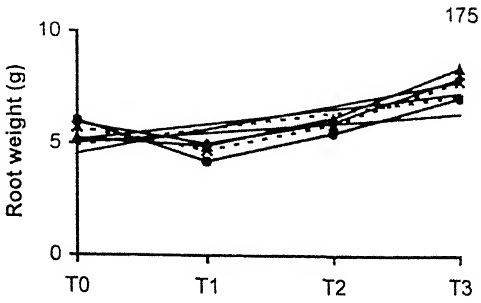
The increase in number of leaves was not substantial at 1Kg a.i./ha. dosage in all the replicates of experimental plants. But thereafter, the number of leaves increasesd uniformly at higher dosages i.e. 2 and 4 Kg a.i./ha ($P < 0.10$) [Fig. 176, Table 22].

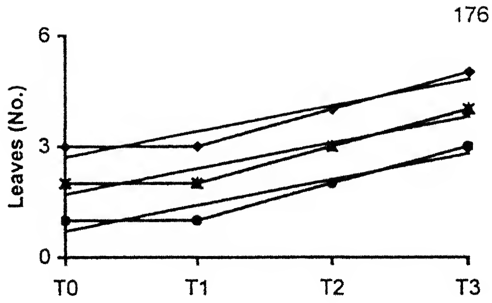
3. Effect on Number of Fruits

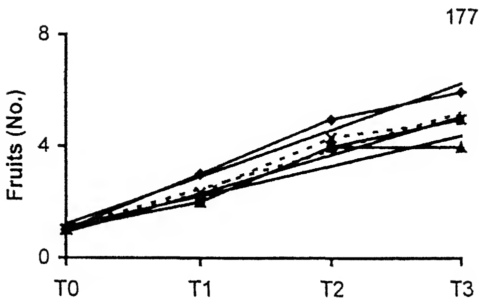
There was uniform increase in the number of fruits observed at increased dosage of Acephate in R_1 replicates. On the contrary, no effective change occurred at 1Kg a.i./ha dosage in R_2 and R_3 replicate. Thereafter, number of fruits increased at 2Kg a.i./ha and further steadied at 4Kg a.i./ha dosage ($P < 0.20$ - $P < 0.10$). [Fig. 177, Table 22].

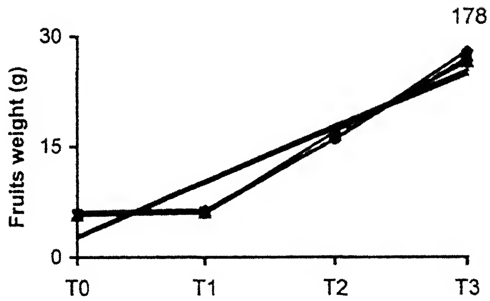
4. Effect on Weight of Fruits

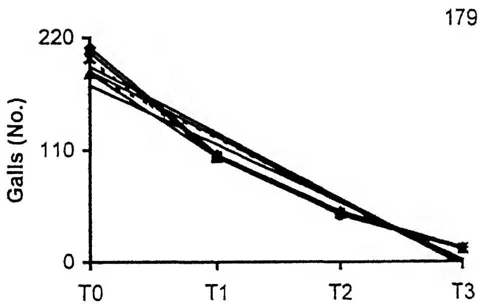
The change in weight of fruits was not substantial at 1 Kg a.i./ha in all the replicates. But consistently increasing influence on the weight of fruits was observed at 2 and 4 Kg a.i./ha dosages of Acephate.


175
Root weight (g)
10
5
0
T0
T1
T2
T3


176
Leaves (No.)
6
3
0
T0
T1
T2
T3


177
Fruits (No.)
8
4
0
T0
T1
T2
T3


178
Fruits weight (g)
30
15
0
T0
T1
T2
T3


179
Galls (No.)
220
110
0
T0
T1
T2
T3

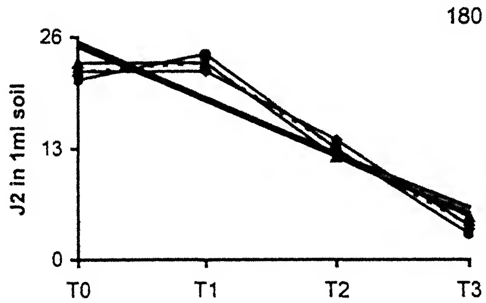

180
J2 in 1ml soil
26
13
0
T0
T1
T2
T3

Table 22 : Linear regression trends depicting variations in ***A. esculentus*** characteristics infesting ***M. incognita*** after post-inoculation soil treatment, two week after germination of plants by Acephate (1kg., 2kg., 4kg per ha.) (s = significant, J2 = second stage Juvenile larva).

Plant growth parameters	**Replicate**	**Linear regression trends**	**Correlation coefficient**	**Level of significance**
Shoot length	R_1	Y = 12.84 + 3.56 X	r = 0.707	$P < 0.100^S$
	R_2	Y = 11.82 + 3.97 X	r = 0.739	$P < 0.100^S$
	R_3	Y = 12.32 + 3.74 X	r = 0.718	$P < 0.100^S$
	Mean	Y = 12.26 + 3.75 X	r = 0.725	$P < 0.100^S$
Shoot weight	R_1	Y = 7.48 + 1.06 X	r = 0.532	$P < 0.200^S$
	R_2	Y = 6.85 + 1.53 X	r = 0.557	$P < 0.200^S$
	R_3	Y = 4.57 + 2.15 X	r = 0.666	$P < 0.200^S$
	Mean	Y = 6.3 + 1.58 X	r = 0.601	$P < 0.200^S$
Root length	R_1	Y = 10.94 + 2.94 X	r = 0.684	$P < 0.200^S$
	R_2	Y = 10.57 + 2.72 X	r = 0.682	$P < 0.200^S$
	R_3	Y = 10.59 + 2.68 X	r = 0.660	$P < 0.200^S$
	Mean	Y = 10.7 + 2.78 X	r = 0.676	$P < 0.200^S$
Root weight	R_1	Y = 5.14 + 0 62 X	r = 0.627	$P < 0.200^S$
	R_2	Y = 4.96 + 0.422 X	r = 0.450	$P > 0.50^{NS}$
	R_3	Y = 4.63 + 0.890 X	r = 0.709	$P < 0.100^S$
	Mean	Y = 4.91 + 0 644 X	r = 0.626	$P < 0.200^S$
Leaves (No.)	R_1	Y = 2.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	R_2	Y = 0.8 + 0.54 X	r = 0.726	$P < 0.100^S$
	R_3	Y = 1.8 + 0.54 X	r = 0.726	$P > 0.100^S$
	Mean	Y = 1.8 + 0.54 X	r = 0.726	$P < 0.100^S$
Fruits (No.)	R_1	Y = 1.6 + 1.22 X	r = 0.709	$P < 0.100^S$
	R_2	Y = 1.2 + 1.02 X	r = 0.721	$P > 0.100^S$
	R_3	Y = 1.4 + 0.771 X	r = 0.658	$P < 0.200^S$
	Mean	Y = 1.39 + 1.0 X	r = 0.704	$P < 0.100^S$
Fruit weights	R_1	Y = 3.82 + 5.88 X	r = 0.730	$P < 0.100^S$
	R_2	Y = 3.55 + 5.77 X	r = 0.728	$P < 0.100^S$
	R_3	Y = 3.85 + 5.66 X	r = 0.726	$P < 0.100^S$
	Mean	Y = 3.74 + 5.77 X	r = 0.729	$P < 0.100^S$
Galls (No.)	R_1	Y = 202 – 80 X	r = -0.656	$P < 0.200^S$
	R_2	Y = 171 – 45.4 X	r = -0.688	$P < 0.100^S$
	R_3	Y = 159.2 – 41.11 X	r = -0.702	$P < 0.100^S$
	Mean	Y = 168.6 – 44.2 X	r = -0.693	$P < 0.100^S$
J2 in 1ml soil	R_1	Y = 24 – 4.85 X	r = -0.728	$P < 0.100^S$
	R_2	Y = 24.2 – 5.11 X	r = -0.697	$P < 0.100^S$
	R_3	Y = 24.4 – 4.94 X	r = -0.715	$P < 0.100^S$
	Mean	Y = 24.2 – 4.97 X	r = -0.716	$P < 0.100^S$

The regression line patterns were significant ($P < 0.10$) [Fig. 178, Table 22].

5. Effect on Number of Galls & J_2 Larvae in Soil

The statistically significant decline in the number of galls as well as J_2 larvae in soil around ***A. esculentus*** were the main features of current study, with 2 weeks post-germination seed treatment with Acephate. The only differentiating feature was that the decline in the number of galls was pretty sharp at all the doses in R_1, R_2 and R_3 replicates. On the contrary, 1 Kg a.i./ha dosage had no effect on J_2 in the soil but thereafter decline in J_2 larvae in soil was very sharp at higher dosage of 2 and 4 Kg a.i./ha. The regression line patterns were highly significant ($P < 0.20$ - $P < 0.10$) [Figs. 179, 180, Table 22].

Comparison of Different Nematicides Against *M. incognita* Used as Post-inoculation Soil Treatment Two Week After Germination of Seeds of A. esculentus

In this experiment all the six nematicides **viz.** Fensulphothion, Carbofuran, Aldicarb, Mocap, Phorate and Acephate were used as soil treatment like in the previous

experiment. But nematicides were applied two weeks after germination of plants. The objective behind it was to test the efficacy of nematicides when applied during growing stage of plants in the post-inoculated stage. ANOVA was performed on the data obtained in the experiment. Further, the comparative trends emerging from ANOVA were substantiated by the evaluation of efficacy of all the six nematicides in terms of different growth parameters. CD was employed on the mean value of three replicates of ***A. esculentus*** mentioned in parentheses.

1. Effect on Shoot Length

The statistical evaluation of data on shoot length revealed high degree of significance ($F_{2,18}$ = 164.00). The highest growth was observed at 4 Kg a.i./ha dosage of different nematicides in the following sequence:

Carbofuran (31.00 cm) > Fensulphothian (30.10 cm) > Mocap (28.70 cm) > Aldicarb (28.35 cm) > Acephate (28.10 cm) > Phorate (28.00 cm).

The least effective doses were 1Kg a.i./ha of Phorate (14.00 cm) and Acephate (14.00) over untreated control (14.10 cm) on the basis of $CD_{5\%}$ = 1.33. The results of ANOVA follow: -

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	1903.8	105.7	164.1	1.99
Replication	2	3.13	1.56		

SE = 0.655 CD 5% = 1.337 CD 1% = 1.803

2. Effect on Shoot Weight

The weight of shoot exhibited statistically significant increase at 4 Kg a.i./ha dosage ($F_{2,18}$ = 126.39) of different nematicides. The sequence in this declining order of superiority was:-

Carbofuran (17.10 g) < Aldicarb (16.80 g) < Fensulphothion (15.10 g) < Mocap (13.40 g).

The nematicides whose application was not effective over untreated control (8.10 g) were 1 Kg a. i. /ha Acephate (5.00 g) < 1 Kg a. i. /ha Phorate (5.10 g) < 1 Kg a. i. / ha Mocap (5.20 g) on the basis of $CD_{5\%}$ = 0.939.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	723.49	40.19	126.40	1.99
Replication	2	5.5871	2.7935		

SE = 0.460 $CD_{5\%}$ = 0.939 $CD_{1\%}$ = 1.266

3. Effect on Root Length

The data on root length when subjected to statistical analysis of ANOVA ($F_{2, 18}$ = 285.89), provided that 4 Kg a. i. /ha dosage of different nematicides were highly significant and effective over untreated controls (13.20 cm). The sequence of their effectiveness was: -

Carbofuran (30.00 cm) < Aldicarb (28.00 cm) < Fensulphothion (27.85 cm) < Mocap (24.10 cm). The nematicides ineffective were 1 Kg a.i./ha dosage of Acephate (11.00 g) and Phorate (11.10 g) on the basis of $CD_{5\%}$ = 1.03.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	1992.6	110.7	285.89	1.99
Replication	2	6.0255	3.0128		

SE = 0.508 $CD_{5\%}$ = 1.036 $CD_{1\%}$ = 1.397

4. Effect on Root Weight

The weight of root increased significantly at 4 Kg a.i./ha dosage of different nematicides ($F_{2, 18}$ = 61.51) in the following sequence:-

Carbofuran (11.75 g) < Fensulphothion (10.80 g) < Aldicarb (10.10 g) < Mocap (7.90 g) over untreated controls (5.70 g) on the basis of $CD_{5\%}$ = 0.739.

The nematicides, that were least effective with non-significant influence were 1 Kg a.i./ha dosage of Acephate (4.70 g) and Phorate (4.80 g).

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	218.37	12.132	61.519	1.99
Replication	2	0.9758	0.4879		

Se = 0.362 $CD_{5\%}$ = 0.739 $CD_{1\%}$ = 0.997

5. Effect on Number of Leaves

Like in the preceding attributes, the number of leaves also recorded a significant increase at 4 Kg a.i./ha dosage of different nematicides. ANOVA ($F_{2,18}$ = 11.22) confirmed the following sequence of their efficacy at 4 Kg a.i./ha:-

Fensulphothion (5.66) < Carbofuran (5.00) < Mocap (4.33) < Aldicarb (4.00).

The least effective nematicides with statistically non-significant influence were 1 Kg a.i./ha dosage of Acephate (2.00) and Phorate (2.00) over untreated controls (2.00) on the basis of $CD_{5\%}$ = 0.941.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	64.59	3.588	11.225	1.99
Replication	2	21.158	10.579		

Se = 0.461 $CD_{5\%}$ = 0.941 $CD_{1\%}$ = 1.269

6. Effect on Number of Fruits

ANOVA proved the following sequence of efficacy at 4 Kg a.i./ha pertaining to the number of fruits ($F_{2, 18}$ = 18.52):-

Carbofuran (5.66) < Alicarb (5.00) = Acephate (5.00) < Fensulphothion (4.66) = Phorate (4.66).

The nematicides with non-significant effect were 1 Kg a.i./ha dosage of Mocap (1.00) and 1 Kg a. i. /ha Phorate (1.00) over untreated control (1.00) on the basis of $CD_{5\%}$ = 1.08.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	141.37	7.85	18.52	1.99
Replication	2	0.74	0.37		

Se = 0.531 $CD_{5\%}$ = 1.084 $CD_{1\%}$= 1.462

7. Effect on Weight of Fruits

The effect on weight of fruits was significant ($F_{2, 18}$ = 1178.42). The order of efficacy at 4 Kg a.i./ha dosage was: -

Carbofuran (29.333 g) < Aldicarb (28.30 g) < Acephate (27.20 g) and 2 Kg a.i./ha dosage of Aldicarb (22.20 g) over untreated control (5.80 g).

The 1 Kg a.i./ha dosage of Fensulphothion (4.90 g), Carbofuran (4.30 g) and Mocap (3.70 g) were effective in the next order of efficacy to result into better yield of fruits in terms of increased weight ($CD_{5\%}$ = 0.731).

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	4093.8	227.43	1178.4	1.99
Replication	2	0.5238	0.2619		

Se = 0.358 $CD_{5\%}$ = 2.04 $CD_{5\%}$ = 0.986

8. Effect on Number of Galls

The number of galls declined substantially at 4Kg a.i./ha dosage of different nematicides, which was highly significant ($F_{2,18}$ = 36.88). The comparative

efficacy of nematicides determined the following sequence:-

Carbofuran (4.00) < Aldicarb (6.00) < Fensulphothion (7.00) over untreated control (166.66). The least effective nematicides were 1Kg a.i./ha dosage of Mocap (107.00), Phorate (105) and Acephate (104.00) on the basis of $CD_{5\%}$ = 20.59.

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	104433.4	5801.85	36.88	1.99
Replication	2	491.614	245.807		

Se = 10.240 $CD_{5\%}$ = 20.890 $CD_{1\%}$=28.161

9. Effect on Number of J_2 in1ml Soil:

The data subjected to statistical analysis by ANOVA ($F_{2,18}$ = 97.99) exhibited that J_2 larvae in the soil around ***A. esculentus*** were highly reduced at 4 Kg a.i./ha of various nematicides. However, the interrelationship between the efficacy of these nematicides under study could be placed under the following sequence: -

Aldicarb (3.00) and Carbofuran (3.00) < Fensulphothion (4.00) and Mocap (4.00).

The least effective and non-significant nematicides were 1Kg a. i. /ha dosage of Acephate (23.00) and Phorate (24.00) over untreated controls (22.00) (CD 5% = 2.17). The detailed data on ANOVA follows: -

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	18	2998.2	166.57	97.991	1.99
Replication	2	6.1404	3.0702		

SE = 1.064 CD 5% = 2.171 CD 1% = 2.927

Effect of Combined Application of Nematicides, Neem cake and Urea as Soil Treatment Against *M. incognita* Infesting *A. esculentus*

The experiments were conducted to test the yield of harvest of ***A. esculentus*** after treatment with different combinations of 0.5 t/ha Neem cake and 15 Kg/ha Urea along with various categories of nematicides **viz.** Fensulphothion, Carbofuran and Mocap. These experiments were undertaken to reduce dependence on nematicides so that the inputs of chemical formulations to agricultural soils could be minimized.

The soil was treated with above combinations one day before sowing of seeds of ***A. esculentus***. ANOVA

was conducted on the data obtained by application of different combination of nematicides. The comparison of different treatments was based on the value of three replicates of the plants. Further, the comparative trends emerging from ANOVA were substantiated by the evaluation of efficacy of all the treatments in terms of an assessment of various growth parameters **viz.** shoot length and weight, and root length and weight. The mean values of three replicates have been mentioned in parentheses.

1. Effect on Shoot Length

A high degree of significance was obtained for the influence of combinations of various nematicides and organic manures on shoot length ($F_{2,11}$ = 80.66). The different treatments showed maximum growth in the length of shoot in the following sequence: -

2Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg/ha Urea (34.10 cm) (T_4) > 2 Kg a.i./ha Carbofuran + 0.5 t/ha 0.5 t/ha Neem cake + 15 Kg/ha Urea (33.80 cm) (T_7) > 2 Kg a.i./ha Mocap + 0.5 t/ha 0.5 t/ha Neem cake + 15 Kg/ha Urea (32.00) (T_{10}). The resultant effects after

these treatments on plants were almost at par with those recorded in un-inoculated controls (33.50 cm).

The least effective dosages were 0.5 t/ha Neem cake (18.00 cm) (T_1) over inoculated but untreated controls (13.10 cm) ($CD_{5\%}$ = 2.42, $CD_{1\%}$ = 3.42) [Fig. 181]. The results of ANOVA are as follows:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	1611.62	146.51	80.62	2.32
Replication	2	40.82	20.41		

SE = 1.100 $CD_{5\%}$ = 2.42 $CD_{1\%}$ = 3.42

2. Effect on Shoot Weight

The statistical analysis of the data on shoot length revealed that all the treatments were significant over inoculated but untreated controls (7.15 g). The maximum growth in order of efficacy were 2Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg a.i./ha 15 Kg/ha Urea (20.00 gm) (T_4) > 2 Kg a.i./ha Carbofuran + 0.5 t/ha 0.5 t/ha Neem cake + 15 Kg a.i./ha 15 Kg/ha Urea (19.60 g) (T_7) > 1 Kg a.i./ha Fensulphothion and Carbofuran with 0.5 t/ha Neem cake and 15 Kg/ha Urea (18.30 g) (T_3).

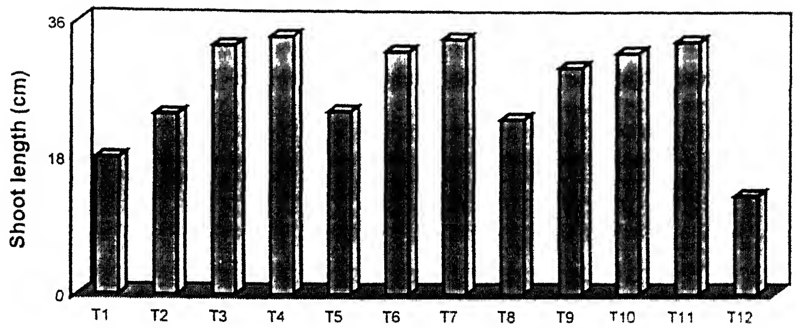
The least effective treatments were 0.5 t/ha Neem cake (10.00 g) (T_1) < 1 Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake (13.10 g) ($F_{2,11}$ = 24.93)[Fig. 182].

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	571.81	57.98	24.93	2.32
Replication	2	11.91	5.95		

SE = 1.178 $CD_{5\%}$ = 2.59 $CD_{1\%}$ = 3.66

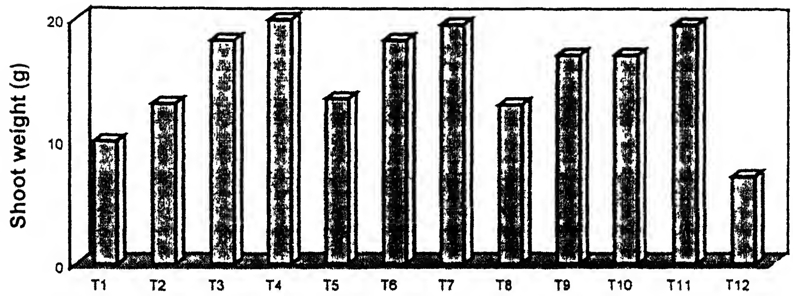
3. Effect on Root Length

The statistical evaluation of the influence of treatment combination on root length ($F_{2,11}$ = 114.51) showed that all the treatments were significant and superior over untreated controls. The order of superiority was 2 Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg/ha Urea (32.60 cm) (T_4) > 2 Kg a.i./ha Carbofuran + 0.5 t/ha Neem cake + 15 Kg/ha Urea (29.90 cm) (T_7) > 2 Kg a.i./ha Mocap + 0.5 t/ha Neem cake + 15 Kg/ha Urea (29.00 cm) (T_{10}). The least effective treatment was 0.5 t/ha Neem cake (14.15 cm) (T_1) over untreated control (12.00 cm) [Fig. 183].



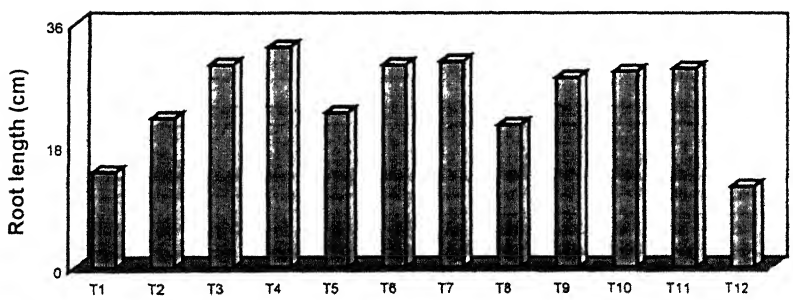
36
18
0
Shoot length (cm)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

181



20
10
0
Shoot weight (g)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

182



36
18
0
Root length (cm)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

183

Source	Df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	1492.9	135.72	114.51	2.32
Replication	2	17.12	8.56		

SE = 0.888 $CD_{5\%}$ = 1.95 $CD_{1\%}$ = 2.76

4. Effect on Root Weight

The data on the weight of root exhibited that all the treatments were statistically significant and effective ($F_{2, 11}$ = 19.29). The detailed data on ANOVA follows:-

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	214.61	19.51	19.29	2.32
Replication	2	15.70	7.85		

SE = 0.821 $CD_{5\%}$ = 1.80 $CD_{1\%}$ = 2.55

The sequence of their efficacy was: -

1 Kg a. i. /ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg/ha Urea (12.46 g) (T_3) > 2 Kg a.i./ha Fensulphothion and Carbofuran with 0.5 t/ha Neem cake and 15 Kg/ha Urea (both 12.10 g) (T_4 & T_7) > Mocap 2 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (10.53 g) (T_{10}). The least effective treatments were 0.5 t/ha Neem cake (5.10 g) (T_1) over untreated plants (5.00 g) [Fig. 184].

5. Effect on Number of Leaves

The statistical analysis of data obtained on efficacy of combination treatment by nematicides and nutrients, on the number of leaves revealed significant influence ($F_{2, 11} = 4.50$).

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	45.63	4.14	4.50	2.32
Replication	2	5.05	2.52		

SE = 0.783 $CD_{5\%}$ = 1.72 $CD_{1\%}$ = 2.43

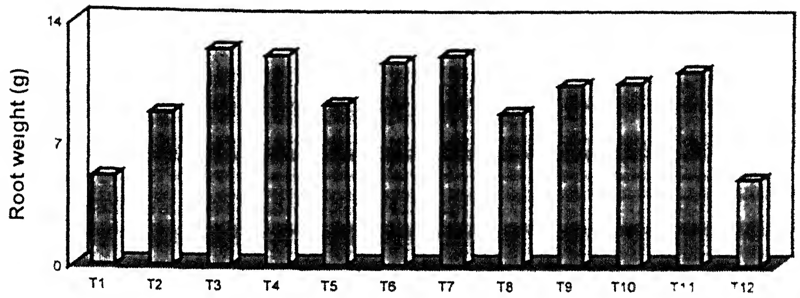
The quantum of production of number of leaves differed during different treatments in the following order of dominating influence:-

Fensulphothion 2 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (6.00) (T_4) > Carbofuran 2 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (5.66) (T_7) > 2 Kg a.i./ha Mocap and 1 Kg Carbofuran and Fensulphothion with 0.5 t/ha Neem cake and 15 Kg/ha Urea (5.00).

The least effective treatments were identified as:-

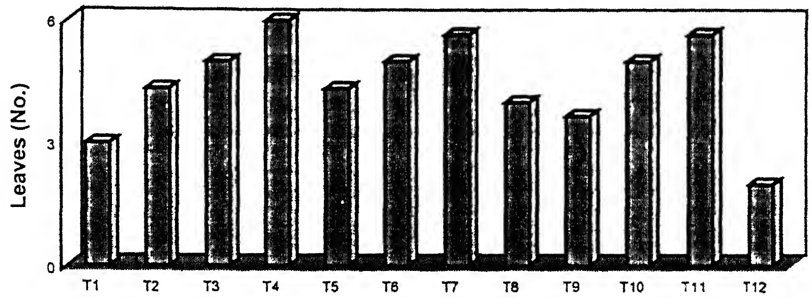
0.5 t/ha Neem cake (3.00) (T_1) < 1 Kg a.i./ha Mocap with 0.5 t/ha Neem cake (3.66) over untreated controls (2.00) [Fig. 185].

6. Effect on Number of Fruits



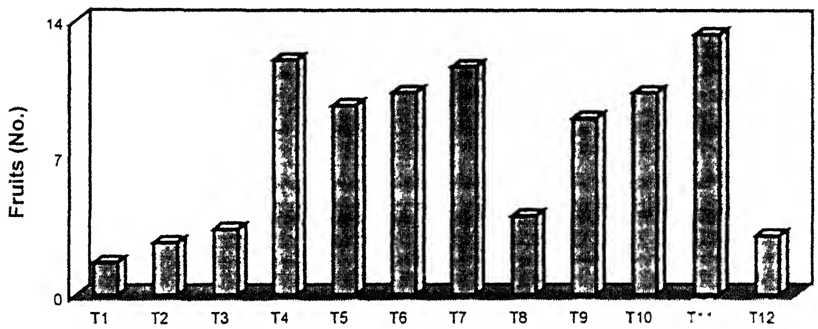
Root weight (g)
14
7
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T12

184



Leaves (No.)
6
3
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

185



Fruits (No.)
14
7
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T12

186

ANOVA provided noticeable significance on efficacy of treatments vis-à-vis yield of fruits ($F_{2,11}$ = 42.98). The sequence, in order of dominating influence, was:-

Fensulphothion (2 Kg a.i./ha) + 0.5 t/ha Neem cake (0.5 t/ha) + 15 Kg/ha Urea 15 Kg a.i./ha (12.00) (T_4) > Carbofuran 2 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (11.66) (T_7) > Mocap 2 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (10.33) (T_{10}). The effect of these treatments was as close as possible to those visible in un-inoculated controls (13.33) (T_{11}).

However, the least effective treatments were-

0.5 t/ha Neem cake (1.66) (T_1) and 1 Kg a.i./ha Mocap + 0.5 t/ha Neem cake (0.5 t/ha). (2.66) (T_8) over untreated controls (2.00) on the basis of $CD_{5\%}$ = 2.03. The detailed data on ANOVA are reproduced below: -

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	605.42	55.038	42.989	2.32
Replication	2	1.1666	0.583		

SE = 0.923 $CD_{5\%}$ = 2.032 $CD_{1\%}$ = 2.873

7. Effect on Fruit Weight

The statistical analysis of data on the efficacy of treatments on weight of fruits revealed that all the treatments were significantly superior over untreated controls. The sequence of their efficacy was:-

2 Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg/ha Urea (68.50 gm) (T_4) > 2 Kg a.i./ha Carbofuran + 0.5 t/ha Neem cake + 15 Kg/ha Urea (67.00 g) (T_7) > 2 Kg a.i./ha Mocap+ 0.5 t/ha Neem cake + 15 Kg/ha Urea (64.30 g) (T_{10}).

The least effective treatments was 0.5 t/ha Neem cake/ha (28.40 g) (T_1) over untreated control (14.80 g) (T_{12}) ($F_{2,11}$ = 226.74) [Fig.187].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	9830.4	893.67	226.74	2.32
Replication	2	51.87	25.93		

SE = 1.620 $CD_{5\%}$ = 3.56 $CD_{1\%}$ = 5.04

8. Effect on the Number of Galls

The statistical evaluation of the data on the efficacy of treatment over the production of number of galls ($F_{2,11}$ = 1518.26) showed high degree of

significance. The different treatments were effective in the following sequence:-

2 Kg a.i./ha Fensulphothion + 0.5 t/ha Neem cake + 15 Kg/ha Urea (2.00) (T_4) < 2 Kg a.i./ha Carbofuran + 0.5 t/ha Neem cake + 15 Kg/ha Urea (3.00) (T_7) = 1 Kg a.i./ha Mocap + 0.5 t/ha Neem cake + 15 Kg/ha Urea (3.00) (T_9) < 1 Kg a.i./ha Carbofuran + 0.5 t/ha Neem cake + 15 Kg/ha Urea and 2 Kg a.i./ha Mocap + 0.5 t/ha Neem cake + 15 Kg/ha Urea (4.00) (T_6 and T_{10}). The least effective treatments were 0.5 t/ha Neem cake (52.00) (T_1) followed by 1 Kg a.i./ha Carbofuran with 0.5 t/ha Neem cake (26.00) (T_5) over untreated controls (201.00) [Fig.188].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	104760	9523.6	1518.3	2.32
Replication	2	24	12		

SE = 2.044 $CD_{5\%}$ = 4.49 $CD_{1\%}$ = 6.35

9. Effect on the Number of J_2 In 1ml Soil

The effect of nematicides plus nutrients' combination resulting into declining density of J_2 in soil revealed high degree of significance ($F_{2,11}$ = 103.12).

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	11	1332	121.09	103.12	2.32
Replication	2	2.16	1.08		

SE = 0.884 $CD_{5\%}$ = 1.94 $CD_{1\%}$ = 2.75

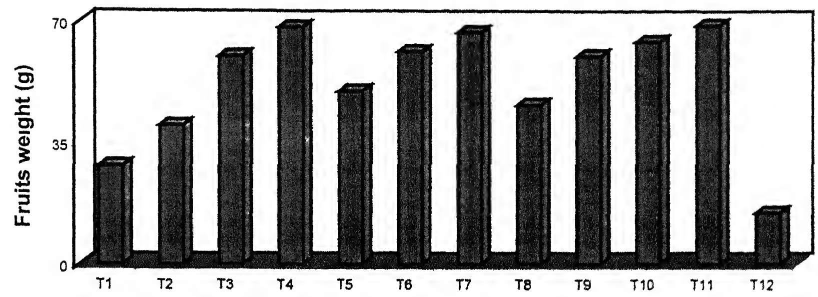
The order of efficacy of different treatments was: -

2 Kg a.i./ha Fensulphothion 0.5 t/ha Neem cake 15 Kg/ha Urea (T_4); 2 Kg a.i./ha Carbofuran, 0.5 t/ha Neem cake 15 Kg/ha Urea (T_7); 1 Kg a.i./ha Carbofuran, 0.5 t/ha Neem cake 15 Kg/ha Urea (T_6); and 2 Kg a.i./ha Mocap, Neem cake 15 Kg/ha Urea (2.00) (T_{10}).

The effects of all the aforementioned treatments were at par with each other.

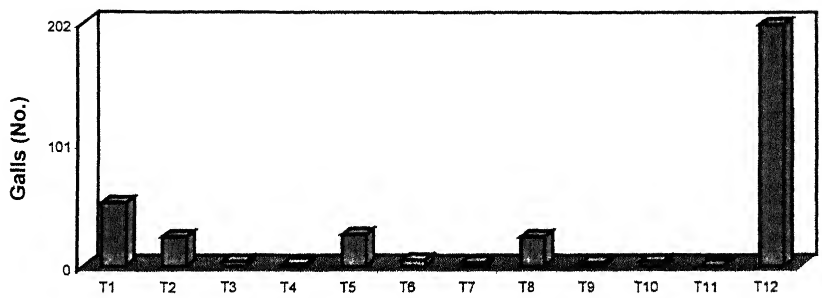
The least effective treatments were 0.5 t/ha Neem cake (12.00) followed by 1 Kg a.i./ha Mocap with 0.5 t/ha Neem cake (8.00) over untreated controls (23.00).

But the effects of all the treatments were statistically highly significant [Fig. 189].



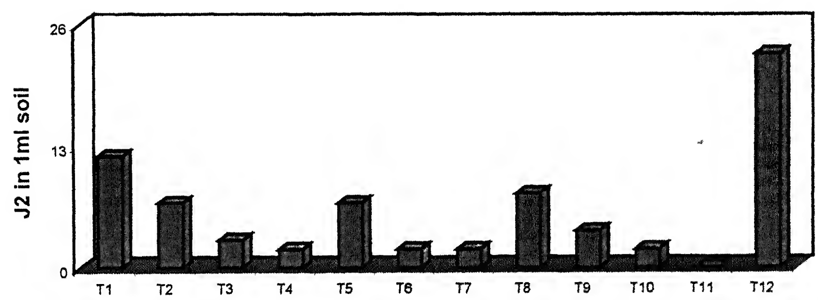
Fruits weight (g)
70
35
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

187



Galls (No.)
202
101
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

188



J2 in 1ml soil
26
13
0
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12

189

Combined Application of Seed Treatment and Soil Treatment Against *M. incognita* on *A. esculentus*

The efficacy of mixed seed treatment with soil treatment to test the control of nemic infestations was the objective of these experiments. The seed treatment is economical and left no residue. The seeds were treated by 1% and 2% doses of different nematicides **viz.** Phorate, Carbofuran, Fensulphothion and Mocap. On the other hand, soil was treated by 0.5 tonne/ha Neem cake, 15 Kg/ha Urea along with 1 Kg a.i./ha of above mentioned different nematicides. The different combinations were already mentioned in Materials and Methods section of this thesis. These experiments were undertaken to reduce the application of nematicides, so that the inputs of chemical formulation to agricultural soil could be minimized. The effect of different combinations of treatments were recorded in context of different growth parameters separately as under. The mean values of the three replicates have been mentioned in parenthesis.

1. Effect on Shoot Length

The statistical analysis of the data on the shoot length proved that all the treatments were significantly superior over untreated controls (13.00 cm). The dominanting influence of different combinations could be summed up into the following sequence:-

Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (36. 60 cm) (T_4) > Fensulphothion (2%) + Mocap (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (34.60 cm) (T_6) > Carbofuran (1%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (33.50) (T_3).

The effects of all the aforementioned combinations in treatment were at par to un-inoculated controls (34.20 cm) (T_9).

The least effective combination was Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (26.10 cm) (T_7) on the basis of CD 5% = 2.19 ($F_{2,9}$ = 85.29) [Fig. 190].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	1255.323	139.480	85.297	2.51
Replication	2	32.186	16.093		

SE = 1.044 $CD_{5\%}$ = 2.19 $CD_{1\%}$ = 3.007

2. Effect on Shoot Weight

The efficacy of combination of treatments on shoot weight ($F_{2,9}$ = 94.51) revealed efficacious influence of all the treatments under study, than untreated controls (7.00 g). The order of efficacy could be summed up as:- Carbufuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (21.90 g) (T_4) > Fensulphothion (2%) + Mocap (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (20.80 g) (T_6) > Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (20.10 g) (T_2).

The effect of these treatments also dominated than un-inoculated controls (19.95 g) (T_9).

The least effective dosage was Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea [Fig. 191].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	552.86	61.429	94.518	2.51
Replication	2	15.392	7.6958		

SE = 0.658238; $CD_{5\%}$ = 1.382301; $CD_{1\%}$= 1.895727

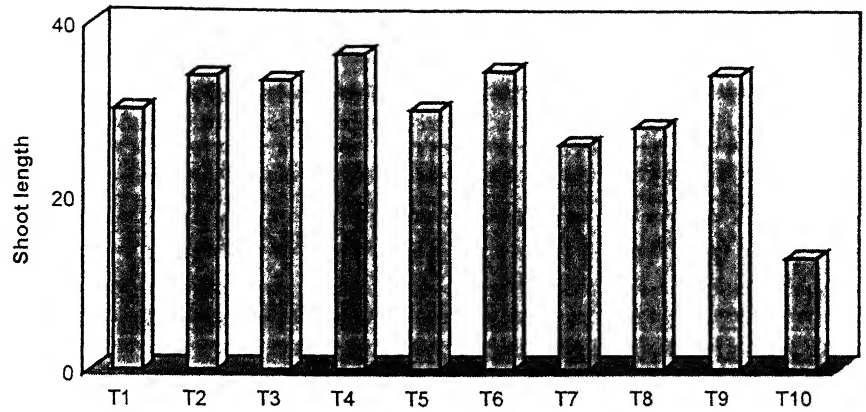
3. Effect on Root Length

The influence of all the treatments was significantly dominating than the results obtained in untreated controls (12.00 cm) ($F_{2,9}$ = 179.23). The maximum growth in the root length was recorded on treatment with- Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (34.40 cm) (T_4). It was followed by Fensulphohtion (2%) + Mocap (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (32.60 cm) (T_6).

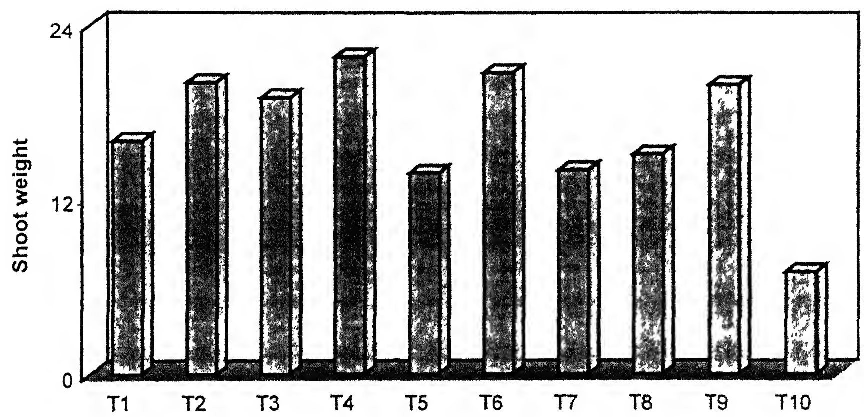
The efficacy of all these were almost at par with those recorded in un-inoculated controls (33.70 cm) (T_9).

The least effective combination was-

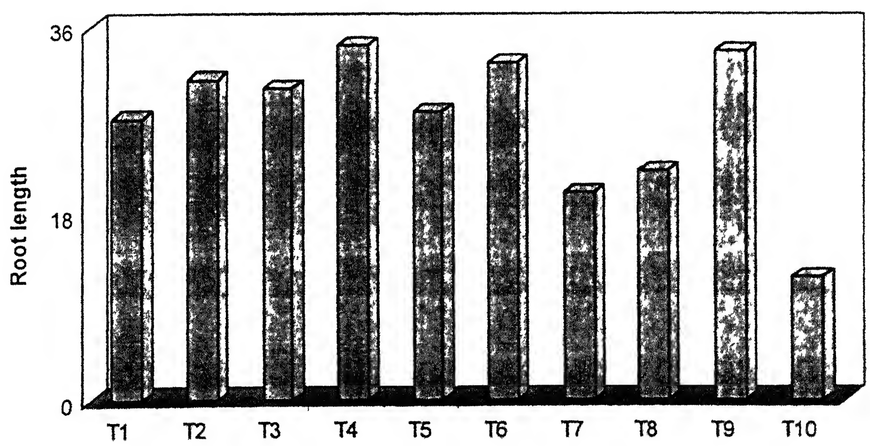
Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (20.10 cm) (T_7) on the basis of $CD_{5\%}$ = 1.57 [Fig. 192].


40
20
0
Shoot length
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

190


24
12
0
Shoot weight
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

191


36
18
0
Root length
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

192

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	1361.4	151.27	179.23	2.51
Replication	2	18.648	9.234		

SE = 0.750 $CD_{5\%}$ = 1.57 $CD_{1\%}$ = 2.16

4. Effect on Root Weight

The efficacy of treatments on weight of roots revealed high significance of the following combination:- Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (13.20 g) (T_4) over un-inoculated control (13.10 gm) (T_9). The other significant combination over untreated control (8.13 g) was Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (12.10 g) (T_2) and Fensulphothion (2%) + Mocap (1Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (12 g) (T_6).

The non-effective and non-significant combination was-

Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (7. 10g) (T_7) on the basis of $CD_{5\%}$ = 3.01 ($F_{2,9}$ = 4.53) [Fig. 193].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	126.408	14.0453	4.5338	2.51
Replication	2	19.98467	9.99233		

SE = 1.437 $CD_{5\%}$ = 3.01 $CD_{1\%}$ = 2.88

5. Effect on Number of Leaves:

The maximum number of leaves were reportedly produced after treatment with Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (6.66) (T_4). This efficacy assessment was identical to the levels attained in un-inoculated control (6.66) (T_9). It was followed by Phorate (2%) + Carbofuran 1 Kg a.i./ha + 0.5 t/ha Neem cake + 15 Kg/ha Urea (5.66) (T_2). The effect of all the treatments were tested statistically and were found significantly different in comparison to the output from untreated controls (2.00) on the basis of $CD_{5\%}$ = 1.20. The least effective treatment was Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (3.00) (T_7) ($F_{2,9}$ = 13.56) [Fig. 194].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	60.133	6.6815	13.564	2.51
Replication	2	6.4667	3.2333		

SE = 0.57 $CD_{5\%}$ = 1.20 $CD_{1\%}$ = 1.65

6. Effect on Number of Fruits

The output in terms of enhanced number of fruits ($F_{2,9}$ = 46.87) could be attained with the following combinations:-

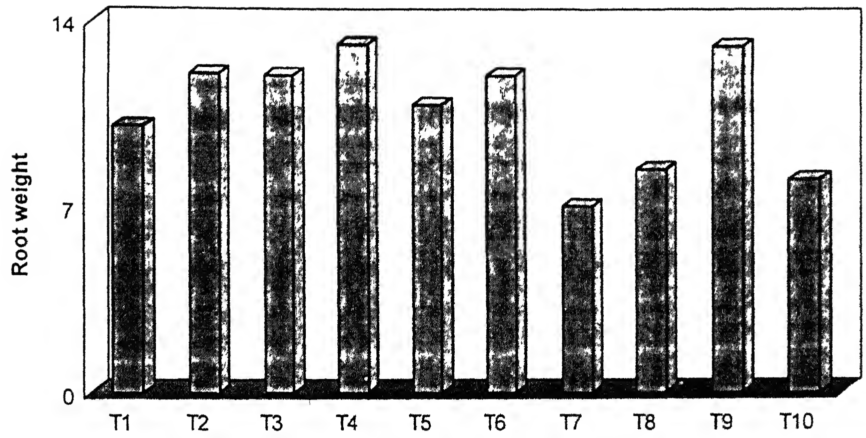
i. Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (13.00) (T_4).

ii. Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (13.00) (T_2).

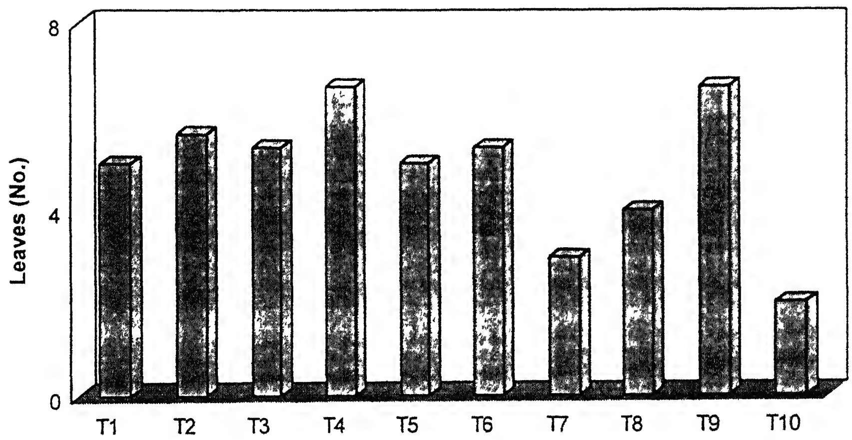
The effects of the aforesaid two combinations were at par amongst each other, and highly significant over untreated control (3.00) (T_{10}) on the basis of CD 5% = 1.44.

The least effective but statistically significant treatment was-

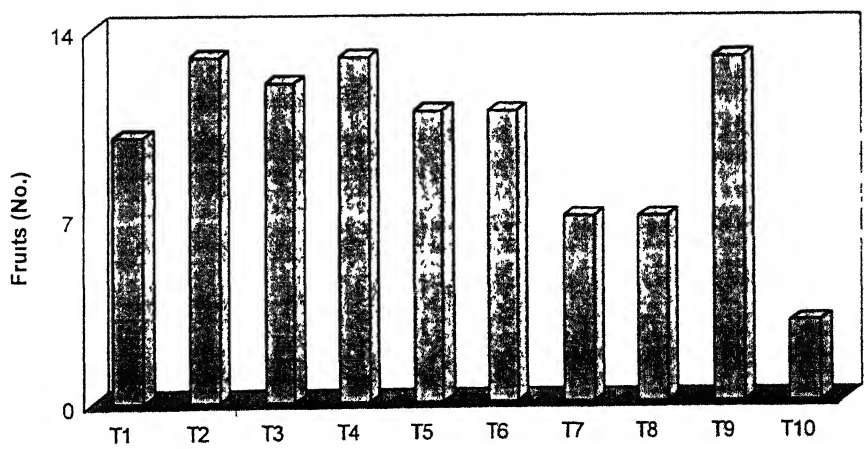
Mocap 1% + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (7.00) (T_7) [Fig. 195].


14
7
0
Root weight
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

193


8
4
0
Leaves (No.)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

194


14
7
0
Fruits (No.)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

195

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	300	33.333	46.875	2.51
Replication	2	7.2	3.6		

SE = 0.688 $CD_{5\%}$ = 1.44 $CD_{1\%}$ = 1.98

7. Effect on Weight of Fruits

The effect of combination of treatments on fruit weight ($F_{2,9}$ = 595.32) proved that all the treatments were highly significant over untreated controls (13.10 gm). The sequence of effectiveness were Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (69.70 g) (T_4) > Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 tonne/ha **Neem** cake + 15 Kg/ha Urea (67.50 gm) (T_2) > Fensulphothion (2%) + Mocap (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (64.40 g) (T_6).

The least effective but significant treatment was Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (36.00 g) (T_7) on the basis of CD 5% = 2.27 and CD 1% = 3.11 [Fig. 196].

Source	df	SS	MSS	F Cal	$F_{5\%}$
Treatment	9	9427.515	1047.50	595.32	2.5
Replication	2	30.248	15.124		

SE = 1.083 $CD_{5\%}$ = 2.27 $CD_{1\%}$ = 3.11

8. Effect on Number of Root-Knot Galls

The efficacy of all treatments to control the occurrence of number of galls in the root of ***A. esculentus*** were highly significant ($F_{2,9}$ = 679.11) over untreated controls (200.00). The maximum reduction was observed with:-

Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (2.00) (T_4).

It was followed by Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (3.00) (T_2), and Fensulphothion (2%) + Mocap (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (3.00) (T_6). The resultant efficacy of these treatments were almost at par with those observed in the un-inoculated group of plants (0.00) (T_9) on the basis of $CD_{5\%}$ = 7.00 [Fig. 197].

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	102079.5	11342.17	679.1717	2.51
Replication	2	77.4	8.7		

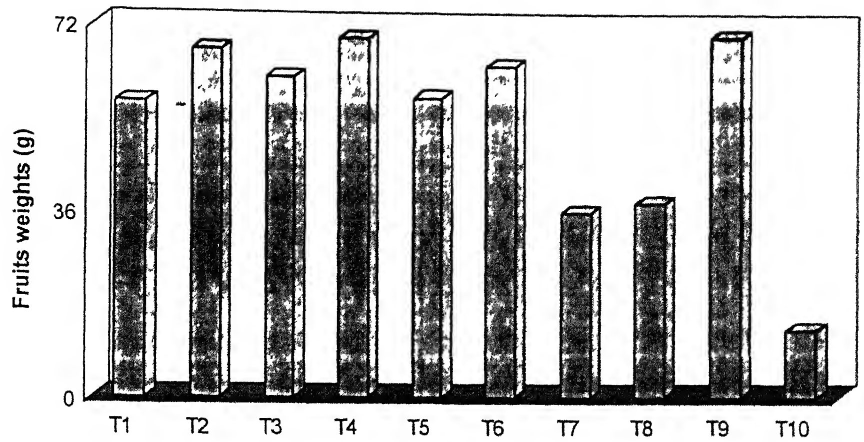
SE = 3.33 $CD_{5\%}$ = 7.006 $CD_{1\%}$ = 9.609

9. Effect on the Number of J_2 In 1ml Soil

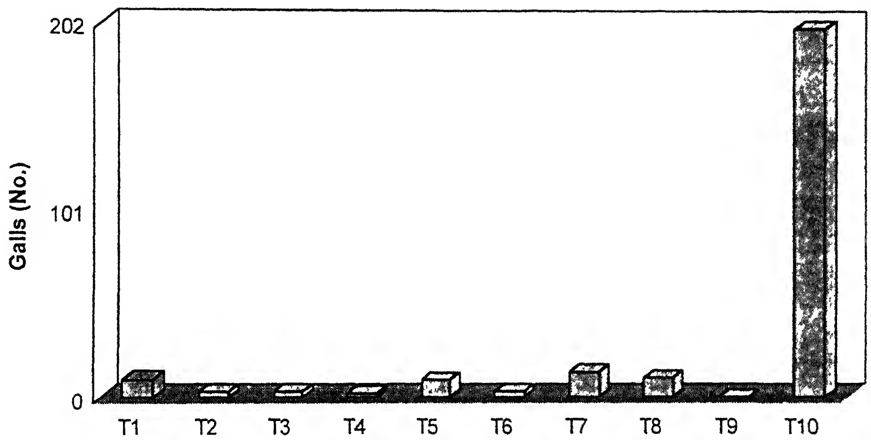
The number of second stage Juveniles (J_2) in the soil around experimental plants were highly reduced by Carbofuran (2%) + Fensulphothion (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (1.00) (T_4) over untreated controls (23.00) (T_{10}). The other statistically significant treatments turned out to be:-

Carbofuran (1%) + Fensulphothion + 0.5 tonne/ha Neem cake + 15 Kg/ha Urea (2.00) (T_3) and Phorate (2%) + Carbofuran (1 Kg a.i./ha) + 0.5 t/ha Neem cake + (2.00) (T_2).

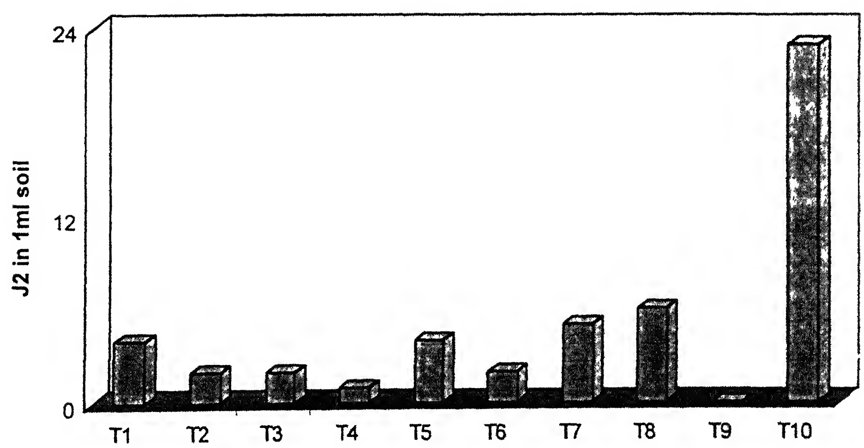
The least effective but significant treatment was Mocap (1%) + Phorate (1 Kg a.i./ha) + 0.5 t/ha Neem cake + 15 Kg/ha Urea (5.00) (T_7) on the basis of $CD_{5\%}$ = 1.54 and un-inoculated control (0.00) (T_9) [$F_{2,9}$ = 161.95] [Fig. 198].


72
36
0
Fruits weights (g)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

196


202
101
0
Galls (No.)
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

197


24
12
0
J2 in 1ml soil
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10

198

Source	df	SS	MSS	F_{Cal}	$F_{5\%}$
Treatment	9	1182.3	131.37	161.96	2.51
Replication	2	5.4	2.7		

SE = 0.735 $CD_{5\%}$ = 1.54 $CD_{1\%}$ = 2.11

DISCUSSION

DISCUSSION

Nemic influence on growth of *A. esculentus*

The evidence of association of nematode inoculum density with the growth of Okra and yield by this plant are available in these investigations. The length of shoot and root, fresh and dry weight of shoot and root as well as the number of leaves, fruits and weight of fruits were negatively correlated with initial populations of J_2 larvae (Figs. 1-9). However, the number of root galls (Fig. 10), number of J_2 larvae in soil (Fig. 11) and J_2 larvae in root (Fig. 12) of experimental plants were positively correlated with intial population of J_2 of ***M. incognita***. Wallace (1963) and Oostenbrink (1966) were of the opinion that the increase in nematode populations and subsequent reduction in the yield of the crop were directly influenced by initial density of the nematodes in soil. Similar correlations were found by Haseeb, Khan and Saxena (1983) on Okra against ***Rotylenchulus reniformis*** and Haseeb and Butool (1989) on ***Ocimum***

sanctum against ***M. incognita***. A corresponding decrease in length of the shoot, root and fresh and dry weight of plants occurred with increase in the initial inoculum level, and the intensity of host reaction (root galling) was directly proportional to the increase in the initial inoculum level.

The inoculum level of 10,000 J_2/Kg soil caused maximum reduction in the length of shoot, length of root, shoot fresh and dry weight, root fresh and dry weights as well as the number of leaves and fruit. It was followed by 1000 J_2/Kg soil inoculum level, that also caused significant reduction in the aforesaid growth parameters. However, the comparative rate of decline in the weight of fruits was relatively slower at 10,000 inoculum level as compared to inoculum level of 1000 J_2/Kg soil (Fig. 9). The density of nematode larvae (J_2) enhanced significantly at a faster rate on 10,000 J_2 inoculum level in soil (Fig. 11). Similar sharp incline occurred in the number of root-knot galls at 10,000 inoculum level when compared with 1000 inoculum level (Fig. 10). Therefore, 1000 and 10,000 J_2/Kg soil inoculum level were highly pathogenic to Okra and reduced yield of the plants with increase in the

number of root-knot galls and J_2 larvae in soil. Lamberti and Baines (1969) reported that trees with 1000 J_2 galled moderately and those with 10,000 J_2 larvae galled severely in their studies on olive trees against ***M. incognita***. Birat (1968) and Jain and Bhatti (1977) concluded that 10,000 and 1000 J_2/Kg soil were more pathogenic and reduced the growth and yield of plants in Okra against root-knot nematodes. Similar findings were reported by Paruthi and Gupta (1985) on bottlegourd against ***M. javanica.***

The inoculum levels of 100 and 10 J_2/Kg soil did not have significant effect on the reduction of various growth parameters of Okra in comparison to uninoculated control. Similar influence of no statistical significance was encountered on the weight of fruits (Fig. 9). Therefore, the lower inoculum density (100 and 10 J_2/Kg soil) had no adverse effect on the growth of Okra plants. The report of Ismail and Saxena (1976) on tomato against root-knot nematodes also emphasized that lower inoculum densities of nematodes had no adverse effect on the growth of plants while the higher inoculum density (1000 larvae) reduced the growth of plants. In recent years Ramana and

Eapen (1995) concluded that ***Meloidogyne*** spp. were the serious constraints to Cardamon cultivation especially in nurseries and black pepper.

If the nemic larvae were mixed in soil at the time of sowing, all the larvae did not have an equal chance to penetrate the root. Therefore, only a fraction of larvae that were located in the vicinity of growing roots might have penetrated the root tissues. Similar instances are expected to occur in the field conditions particularly when sowing takes place in the infested soil. On the contrary, as observed in present experiment, when larvae were inoculated nearer to the root zone, most of these resultantly produced a higher number of galls and egg masses. Hence the severity of disease is generally more intense in pot experiments than under field conditions. The relative data on multiplication rate of ***M. incognita*** revealed that this developmental attributes did not record substantial increase at 10,000 J_2/Kg soil inoculum level in comparison to 1000 J_2/Kg soil inoculum level. Poorer multiplication at the higher inoculum level has been described due to more competition for food and space (Seinhorst, 1965, 1966, 1967). It has been illustrated

that the higher density of nematodes produced severe root-knot disease and reduced the volume and efficiency of the root system. The heavily infected roots are relatively shorter than the healthier roots with fewer laterals and root hairs. The reduced root system absorbed water and nutrients from a limited volume of soil. The normal translocation of water and nutrients was also hampered because of the breakdown of vascular elements. These abnormalities caused stunted growth of plants accompanied by yellowing and withering of leaves, and finally less flowering and fruiting. The adverse effect of higher density of root-knot nematodes on the growth and yield of plants recorded in this investigation is also in agreement with the findings of Dhawan and Sethi (1976) and Srivastava and Upadhyay (1974) on brinjal against ***M. incognita***; Varaprasad (1977) on Sugarbeet; and Swaroop and Sharma (1965), Gunashekharan, Ramaswamy, Kalyanaraman and Vijayraghavan (1969), and Reddy (1985) on tomato against root-knot nematodes.

Penetration and life cycle of *M. incognita* on *A. esculentus*

The results showed that the penetration of second stage juvenile (J_2) larvae started within 12 hours of inoculation. The maximum penetration recorded was 70.66%. This suggested that under colder conditions of 23^0 C thermal regime during day and 18^0 C night in current investigation, the maximum activity of J_2 of ***M. incognita*** was encountered within 48 hrs after inoculation. According to Ngundo and Taylor (1975) penetration of freshly hatched larvae of *M. incognita* and ***M. javanica*** was facilitated within 48 hrs. in bean roots at $21\text{-}24^0$ C.

The observations on the life cycle of ***M. incognita*** revealed completion of its life cycle (**i.e.** from J_2 stage to next J_2 stage) within 33 days of inoculation during experiments on potted Okra plants cultivar Pusa sawani in February (temperature: 23^0 C during day and 18^0 C during night). After penetration of J_2, second

moulting occurred in 8 days and final moulting occurred to transform larvae into young male and female in 21 days.

The nematode development is frequently influenced by the varieties within the plant species as well as on their relative susceptibility to nematodes. It was also concluded during current investigation that the increased length of time interval was required at declining temperature to complete the nemic life cycle.

The investigation showed close agreement in this regard to the findings of Rao and Israel (1973) and Siddiqui and Taylor (1970) exhibiting completion of life cycle by ***M. naasi*** in 39 - 51 days during 26^0 C day and 20^0 C night temperature on wheat. Siddiqui (1986) reported that juveniles feed, grow and become sausage-shaped in 2-3 weeks. These undergo three further moults. The adult females become spheroidal and in about 15-30 days of feeding and growth start laying eggs in gelatinous matrix.

Screening of Okra varieties against *M. incognita* infestation

The experiments were performed to test the potential of resistance in the ten different varieties of Okra against sustained nematode infestations. The indicator of susceptibility was the root gall index on 0 to 5 scale. None of the varieties tested could fall under the category of "highly resistant", "resistant" or "moderately resistant" to the infestation by ***M. incognita***, because all the tested varieties supported more than 50 galls (root gall index > 2) towards the particular population of nematodes. Three varieties **viz**. Spiny, Clemson spineless and Red V_6, V_9 and V_{10} respectively (Figs. 17-18) were graded as "moderately susceptible". In the next grade, the other five varieties in decreasing order of susceptibility were Pusa Sawani (V_1); Long green (V_2); 5 - Dhari (V_5), Vaishakhi vadhu (V_7) and White violet (V_8). The remaining two varieties Padra 18-6 (V_3) and Dong - 10 ridged (V_4) emerged as "highly susceptible", as they supported more than 100 root-knot galls/ plant (root gall index 5) (Fig. 18). Vawdrey and

Sterling (1997; Rev. Loughrey, 2001) recorded an 800-fold increase in nematode numbers within the life of one tomato crop. As per their conclusions though all the crops they tested, hosted nematodes, but only capsicum and sweet corn were sufficiently tolerant of this infestation not to suffer a yield reduction. In their experiments the pre-plant nematode/ml soil density introduced as 4 increased to 3106 nematodes per 200 ml of soil at harvest. This, in fact was reflected into 36% yield reduction on tomato crop with a root gall index, 3.5. In an earlier study, Luna (1998) also recorded severe root galling represented by a root gall index as high as 9.7 on a 1 to 10 scale showing 100% galled roots at 10.

Alam, Khan and Saxena (1974) evaluated seven varieties of Okra against ***M. incognita*** and reported that none of the varieties were "resistant" or "moderately resistant" against ***M. incognita***. Thakar and Patel (1986) also evaluated seven varieties of Okra against ***M. incognita*** and ***M. javanica*** and reported that none of the varieties of Okra were found "resistant" or "moderately resistant". Therefore, the studies of Alam **et al.** (1974) and Thakar and Patel (1986) were in concurrence with the

findings of the author's experiments. The results obtained in the present investigation displayed Pusa Sawani as "susceptibile" variety. This kind of potential of this variety could be verified by the outcome of pathogenicity test reported in the preceding text (Figs. 1-12). Under the stress of nemic invasions accompanied by their manifestation in root-knot, a substantial resultant detrimental influence on the reduced length and weight of shoot and root was encountered in Padra – 18-6 and (V_3 in Figs. 13-16) varieties.

Effect of seed treatment against *M. incognita* on *A. esculentus*

All the six nematicides tested in this experiment showed positive correlation between dosage of nematicides and the length of shoot and root, weight of shoot and root, number of leaves, fruits and weight of fruits (Figs 19 - 25, 28 - 34, 37 - 43, 46 - 52, 55 - 61 and 64 - 70). The negative correlation could be established between dosage of nematicides and the number of root-knot galls and J_2 larvae in soil (Figs 26, 27, 35, 36, 44, 45, 53, 54, 62, 63 71, 72). But Fensulphothion, Carbofuran and Aldicarb were found to be more effective at 3% dosage to increase growth of shoot and root length and their weight; number of larvae, fruits, weight of fruits than Mocap, Phorate and Acephate at 3% dosage. Jain and Gupta (1990) found that various growth parameters of Okra increased at 3% dosage of Aldicarb and Carbosulphan. SivaKumar, Kuppusamy and

Meerzainuddin (1973) applied 3%, 6% and 12 % dosages of Carbufuran as seed treatment on Okra and found that nematode infestations were reduced at 6% dosage. The 2% w/w dosage of Fensulphothion on root weight (Fig 22), number of leaves (Fig 23) and fruits (Fig 24); 2% Carbofuran on number of leaves (Fig 32); 2% Phorate on weight and number of fruits (Figs. 51,52) were also found significantly superior and positively correlated with respective attributes.

Gogoi and Phukan (1990) recorded decrease in the number of galls and increase in other growth parameters and yield by the application of 2% dosage of Carbofuran and Phorate nematicides on lentil against ***M. incognita***. They reported that the maximum plant height was recorded in treatment with 2 % Carbofuran in pot and with 2% Phorate in field. Varaprasad and Mathur (1980) concluded that 1% Carbofuran and 2 % Aldicarb were effective in improving plant growth of sugarbeet. The 1%, 2% and 3% dosages of Carbofuran and Phenamiphos

were also effective to reduce root-knot galls and increased plant growth in bitter gourd (Pankaj and Siyanand, 1992).

The most interesting finding of the present study was the maximum reduction in the number of root-knot galls (Figs. 26, 35, 44, 53, 62, 71) on application of all the six nematicides at their 1% dosage. The evidence is, therefore, available to indicate that lower dosage of nematicides reduced the root-knot disease severity and provided maximum protection to the plants in their initial phase of growth by reducing the penetration of nemic larvae. Similar findings were concluded by Mishra (1985) that penetration of ***M. incognita*** reduced in eight pulse crops on pre-treatment of seed by Aldicarb, Carbofuran, Fensulphothion and Phorate at 1% and 2% w/w dosage. Hong and Sethi (1988) also found that 1% and 2% dosage of Carbofuran were effective against ***M. incognita*** on French bean.

Joshi and Patel (1996) reported that low dosage **viz**. 0.5%, 1% and 1.5% of Carbofuran

significantly improved plant growth in ***M. incognita*** infested groundnut. However, in the current experiment 1% dosage of Acephate was not effective except on number of leaves (Fig. 68) probably due to its low nematostatic action.

The possibility was expressed by Siyanand, Kaushal and Shethi (1986) that partly due to the repellant or nemostatic action of the nematicides, the reproductive physiology of the nematodes is under negative influence in some manner. Under such kind of influence for certain length of time the consequential delay in penetration into the treated seedlings by the root-knot nematodes could occur. It is quite likely that the area around seed might record a noticeable decline in nematode population density due to nematicidal action. Further, the chemical interactions could also prolong the life cycle of the nematodes.

Therefore, conclusively seed treatment in Okra was more effective due to the smooth surface and bolder size of seeds, which facilitated direct

contact of nematicides and other nutrients with seed coat and provided greater surface area for adsorption and absorption.

It could thus be inferred that the highest strength (3%) of Fensulphothion, Carbofuran and Aldicarb, applied during experiments were significantly superior over other treatments. The next in order of efficacy were 3% dosage of Mocap, Phorate and Acephate in terms of better plant growth and reduction in nematode larvae, as well as decline in the number of root-knot galls.

Weingartner, Shumaker, Smart, Dickson (1976) found that Aldicarb 10g and Carbofuran 10 g reduced secondary infection by virus, and improved tuber quality. On the contrary, Ethoprop 10g was less effective in comparison to Aldicarb and Carbofuran. Kuch and Teo (1978) reported the chemical control of root-knot nematodes in ***Piper nigrum*** and found that Carbofuran (0.15%) enhanced fresh weight of roots and average root length and simultaneously reduced the density of nematodes.

Pre-inoculation application of nematicides in soil treatment one day before sowing:

Fensulphothion (Terracur P or Dasanit):

The length of shoot (Fig. 73), root (Fig. 75) and weight of shoot (Fig 74), root (Fig. 76), fruits (Fig 79) as well as the number of leaves (Fig. 77) attained maximum increase after the application of 4 Kg a.i./ha dosage of Fensulphothion against ***M. incognita***. Along with the above growth parameters, the number of root-knot galls (Fig. 80) and J_2 larvae in soil (Fig. 81) around ***A. esculentus*** reduced to their minimum level at the same concentration of nematicide. However, augmentation in growth of the number of fruits was noticed (Fig. 78) at 2Kg a.i./ha dosage of Fensulphothion, which was at par with the products achieved at 4Kg a.i./ha dosage. The result of experiments on application of 2 and 4 Kg a.i./ha doses of Fensulphothion by Sitaramaiah and Vishwakarma (1978) on Okra against ***M. incognita***, one day before

sowing of plants exhibited maximum yield of Okra at 4Kg a.i./ha dosage. According to their illustrations the increase in the yield of Okra was associated with reduction in the number of root-knot galls. Thus the evidence is available in literature to prove the negative impact of nematicide applications to the detriment of larvae of ***M. incognita*** on Okra, which resulted into the enhanced yield of the plant.

Therefore, it is conceivable that the low root-knot nematode population densities due to pre-inoculation soil treatment protected the crop in its early phase of growth. Thus it appears likely that any damage resulting from later infection by secondary sources like bacterial, fungal and viral diseases could be masked.

In the present experiment it was also found that the maximum reduction in the root-knot galls (Fig 80) occurred at 1 Kg a. i. /ha dosage of Fensulphothion and thereafter uniform reduction indicated the efficacy of all the three dosages. It was similar to the finding of Sivakumar, Rajagopalan, Meerzainuddin (1974). They reported that 1 Kg /ha dosage of Fensulphothion was

effective to control root-knot nematodes on tomato. The different methods and rates of application of granular nematicides for the control of root-knot nematodes of tobacco were compared by Reddy and Singh (1979). The spot application at 1Kg a.i./ha and row application at 4 Kg a.i./ha dosage of Fensulphothion to tobacco seedlings planted in the soil infested with ***M. incognita* and *M. javanica*** increased yield of cured tobacco leaves and decreased root galling. But Reddy and Seshadri (1971) reported that Fensulphothion was effective against ***M. incognita*** at higher doses (16 Kg and 32 Kg/ ha) at which they were phytotoxic to the tomato plants.

Carbofuran (Furadon or Curatter):

The length and weight of shoot and root (Figs. 82 - 85) increased maximum by the application of Carbofuran at 4 Kg a.i./ha dosage used as pre-inoculated soil treatment. While number of leaves (Fig. 86), number of fruits (Fig. 87) and weight of fruits (Fig. 88) were maximum at 2 Kg a.i./ha dosage, the maximum reduction in the number of root-knot galls (Fig. 89) and J_2 larvae in soil (Fig. 90) were found at 1 Kg a.i./ha dosage. It

indicated that Carbofuran is effective to increase yield and reduce root-knot disease severity of the plants even at 1 Kg a.i./ha dosage.

It was demonstrated by Ishwarabhat and Krishnappa (1990) that Carbofuran applied at 4 Kg a.i./ha at the time of inoculation of ***M. javanica*** in groundnut seedlings was most effective in controlling the nematodes, besides increasing host growth. Joshi and Patel (1996) reported that 3 Kg a.i./ha dosage of Carbofuran increased plant growth significantly in groundnut against ***M. Javanica.*** The control of root-knot nematodes and increased yield of tomato were also confirmed at 0.6 Kg a.i./ha dosage of Carbofuran by Sivakumar **et al**. (1974). Brodie, Good, Jaworski and Glaze (1968) found excellent plant growth in Okra with application of Carbofuran that reduced secondary viral infection by insects. Thus the prospects appear very promising to control both insects as well as nematode infections simultaneously with the use of Carbofuran in appropriate dosage. The grower can expect to receive additional benefits in lowered unit production cost as well as the reduced use of pesticides (Sitaramaiah and Vishwakarma 1978). Karanja (1996) and

Sikora (1996) from Nairobi, Kenya and Bonn respectively illustrated that Carbofuran was effective to reduce root galling in bean plant, while 12% ***Bacillus*** isolates were more effective than Carbofuran in reduction of root galls. Cassasa, Matheus, Crozzoh and Casanova (1995) illustrated that Carbofuran was effective to reduce the root galling in ***Psidium guajava***. The root-knot nematode infection was effectively checked with 50g Carbofuran at the time of planting and 100 g/vine twice a year by Zaki and Maqbool (1991). But 4 Kg a.i./ha dosage of Carbofuran failed to increase plant growth as well as to reduce nematode populations of ***M. incognita*** in soil around sunflower (Amarnatha and Krishnappa, 1992). Hoda and Youssef (2001) demonstrated that in soil treatment organic manures, inorganic fertilizers or Carbofuran were highly successful (66.7%) in reducing nematode density in the integrated control of ***M. incognita*** infecting cowpea.

Echavez - Badel (1989) also reported the efficacy of Carbofuran against root-knot nematodes on common bean and Mung bean. The detrimental effect of Carbofuran on plant growth observed by Sakhuja and

Sethi (1986) revealed Carbofuran to be effective only at 1.5 Kg a.i./ha dosage in reducing the nematode population and boosting shoot weight. But this nematicide proved to be detrimental to peanut growth at 3 Kg a.i./ha dosage. Minton and Morgan (1974) also confirmed toxicity of Carbofuran to groundnut. Reddy and Seshadri (1971) found Carbofuran to be effective at 16 Kg and 32 Kg a.i./ha dosage, at which these were phytotoxic to tomato plants.

Mocap (Ethoprop):

The increased growth of length of shoot and root (Figs. 91, 93) and weight of shoot and root (Figs. 92, 94) were attained by pre-inoculation treatment of soil by 4 Kg a.i./ha dosage of Mocap, while maximum increase in the number of leaves (Fig. 95), number of fruits (Fig. 96) and weight of fruits (Fig. 97) were encountered at 2 Kg a.i./ha dosage. Though maximum reduction in the number of root-knot galls of experimental plants was attained at 1 Kg a.i./ha dosage, yet the other growth parameters **viz.** length and weight of shoot, roots and fruit as well as length of root, number of leaves and fruits were at par

with untreated control. The effective reduction in development and reproduction of nematodes was achieved with improved plant growth by Amarnatha and Krishnappa (1992) in sunflower plants against ***M. incognita*** with the application of 4 Kg a.i./ha dosage of Mocap. In the similar fashion Sitaramaiah and Vishwakarma (1978) reported that after Fensulphothion, efficacy of 4 Kg a.i./ha dosage of Mocap was effective to increase the yield of Okra against ***M. incognita*** infection. Some of the earlier findings yielding maximum fruits in brinjal after soil treatment by Mocap as well as Aldicarb and Fensulphothion @ 2 Kg. a.i./ha (Singh, Rao and Parvatha Reddy, 1978) showed agreement with the findings in current investigation. But Ishwarbhatt and Krishnappa (1990) reported that 2 Kg a.i./ha dosage of Mocap was the least effective on groundnut. Hagen and weeks (1986) found that the number of juveniles were not reduced by the application of Mocap. Cassassa **et al** (1995) recorded diminishing nematode populations at 4g a. i. /tree dosage of Ethoprop on ***Psidium guajava*** against ***Meloidogyne*** infestations.

Phorate (Thimet):

The highly increased growth of the length of shoot (Fig. 100), root (Fig. 102), weight of shoot (Fig. 101), root (Fig. 103) and fruits (Fig. 106) as well as the number of leaves (Fig. 104) and fruits (Fig. 105) were attained by the pre-inoculation soil treatment of 4 Kg a.i./ha dosage of Phorate one day before sowing of seeds of ***A. esculentus***. Simultaneously, sharp decline in the number of root-knot galls (Fig. 107) was encountered at 1 Kg a.i./ha dosage. The experimental evidence provided by Amarnatha and Krishnappa (1992) on pre-inoculation treatment of 4 Kg a.i./ha dosage of Phorate for the best plant growth in sunflower against ***M. incognita*** in terms of shoot length, number of leaves, fresh weight and dry weight of roots were in agreement with the conclusions of the current investigation.

Joshi and Patel (1996) found that higher dosage (3 Kg a.i./ha) of Phorate improved plant growth attributes followed by its lower dosage (1 and 2 Kg a.i./ha) on groundnut against ***M. javanica***. These observations conform to the findings of present experiment. The report of Sitaramaiah and Vishwakarma (1978) emphasized similar results with maximum yield in tomato and Okra on

pre-inoculation soil treatment by 2 Kg a.i./ha dosage of Phorate against ***M. javanica*** and ***M. incognita***. The yield further increased at higher dosage treatment. All the three dosages of Phorate differed significantly from each other in manifestation of plant growth attributes in this experiment. The shoot weight enhanced (Fig. 101) and maximum reduction in number of root-knot galls (Fig. 107) occurred at treatment with 1 Kg a.i./ha dosage of Phorate. But at this dosage (1 Kg a.i./ha), other growth parameters were not influenced, and showed the results at par with untreated control (Figs. 100 & 102 - 106). Singh **et al.** (1978) concluded that 1 Kg a. i. /ha Phorate gave the least yield which was not significantly different from Phorate at 1.5 Kg a.i./ha and untreated control on brinjal against root-knot nematodes in the pot experiments. The corn rootworm white grubs and mites infestation can be effectively managed with the use of Phorate. The sweet corn growers applied 1.1 to 1.6 pounds of active ingredients of Phorate per acre to control nematode infectivity which was illustrated in field corn nematode management by KinLoch and Rich (2001). Zaki and Maqbool (1991) illustrated that the treatment of

planting pit of vine with 15 gm Phorate provided protection against phytonematodes.

Aldicarb (Temik):

The enhanced shoot length (Fig. 109), shoot weight (Fig. 110), root length and weight (Figs. 111 & 112, respectively), number of leaves and fruits (Figs. 113, 114) and maximum reduction in root- knot galls (Fig. 116) and J_2 in soil (Fig. 117) were attained with 1 Kg a.i./ha dosage of Aldicarb. The above growth parameters further increased at 2 Kg a.i./ha and peak attained at 4 Kg a.i./ha dosage. On the contrary, the weight of fruits did not increase at 1 Kg a.i./ha dosage (Fig. 115), but steep increase occurred at 2 Kg a.i./ha dosage with maximum at 4 Kg a.i./ha dosage.

Sitaramaiah and Vishwakarma (1978) provided evidence of significantly greater yield in Okra plants in pots treated with Aldicarb against ***M. Incognita*** infestation than from the plants treated with Mocap or Phorate or untreated controls. The maximum reduction in the yield of Okra at higher dosages **i.e**. 6 and 8 Kg a.i./ha of these nematicides as well as reduction in the maximum weight of shoot, root and height of plants occurred with

Aldicarb treatment after 60 days. It also reduced the incidence of yellow mosaic of Okra. The severity of root-knot disease in plants was considerably lower at all the three dosages of Aldicarb (Figs. 116, 117) which indicated that it reduced larvae population (Fig. 117) and protected the crop, resulting into better growth. Its nematicidal and insecticidal properties protected plants in their later stage of growth resulting into maximum yield. Jain and Gupta (1990) also provided evidence that 1 Kg a.i./ha dosage of Aldicarb significantly increased the yield in Okra plants infecting ***M. javanica***. Sivakumar **et al.** (1974) reported that spot application of 1.0 Kg a.i./ha dosage of Aldicarb gave significantly higher yield and was effective to control root-knot on tomato. Reddy and Seshadri (1971) reported that Aldicarb was the most effective of the chemicals used in pre-inoculation treatment where 4 to 8 Kg a.i./ha dosages practically eliminated infection by the root-knot nematodes ***M. incognita*** in tomato. These treatments completely prevented the entry of nematode larvae into the roots. The non-phytotoxic dosage of Aldicarb indicated that the elimination of root-knot infection in the pre-inoculation treatment of this chemical may be due to

purely nematostatic action and significant reduction in nematode multiplication in all the dosage of Aldicarb indicated systemic action of the nematicide. The fruit yield in ***Citrus sinensis*** was significantly increased by 20 g/tree dosages pre-inoculation soil treatment by Aldicarb against plant-parasitic nematodes (Siddiqui, Rashid, Farooqui and Bisheya, 1987). Queneherve (1991) found that Aldicarb gave more consistent results in mineral soils to reduce nematode populations and to optimize the vegetative growth in addition to the total harvest of banana. Weingartner (1987) reported that Aldicarb @ 3 lb/acre increased potatoes' yield and it also affected considerably population densities of ***M. incognita.*** The efficacy of FMCF7825 at 2.0 lb /acre and Aldicarb 3.0 lb/acre showed similar strength to reduce population of ***M. incognita*** on potato (Weingartner 1987).

Weingartner and Shumaker (1990) reported control of ***M. incognita*** and soil born diseases with Aldicarb (3.4 Kg a.i./ha) in potatoes and the most effective control was provided by the combination of 1.3-Dichloropropene (1.3-D) and Aldicarb. Weingartner and Shumaker (1990) reported that ethyl bromide or ethyl

bromide + **chloropicrine** in combination with Aldicarb provided effective control over root-knot nematodes. Aldicarb did not enhance the control of bacterial wilt. In 1983, 23.9 % (P = 0.0001) of the variability in the number of wilted plants per plot (Y) was described by the equation Y = 3.03 + 0.67 X, where X = ***M. Incognita*** per 100 cm^2 soil at harvest.

Acephate (Orthene):

The effective increase in the length of shoot and root, the weight of shoot and root alongwith number of leaves (Figs. 118-122) occurred by the application of 4 Kg dosage of Acephate in their pre-inoculation soil treatment. While 2 Kg a.i./ha dosage was effective to increase fruit number (Fig. 123) and fruit weight (Fig. 124) and reduced J_2 larvae in soil (Fig. 126), its lower dose (1 Kg a.i./ha) Acephate was not effective to increase various growth parameters its efficacy was at par with untreated control. It was probably due to its low nematostatic action at the lower dosage. Jain and Bhatti (1978) concluded no significant improvement in yield and gall number reduction at 500 ppm dosage of Acephate on tomato against root-knot nematodes.

Post-inoculation Application of Nematicides

Soil treatment one week after inoculation:

The varied dosages of 2 and 4 Kg a.i./ha of Fensulphothion, Carbofuran, Mocap, Phorate and Acephate were significantly effective to increase the various growth parameters in terms of shoot length (Figs. 127, 136, 145, 154, 172), shoot weight (Figs. 128, 137, 146, 155, 173), root length (Figs. 129, 138, 147, 156, 174), root weight (Figs. 130, 139, 148, 157, 175), number of leaves (Figs. 131, 140, 149, 158, 176), fruits (Figs. 132, 141, 150, 159, 177) and weight of fruits (Figs. 133, 142, 151, 160, 178). These post-inoculation treatments also succeeded in reducing the number of J_2 larvae in soil (Figs. 135, 144, 153, 162, 180). However, an effective decline in the number of root-knot galls (Figs. 134, 143, 152, 161, 179) was encountered at the minimum dose of 1 Kg a.i./ha of all the nematicides under study. It was interesting to note that all the doses of Aldicarb applied (1 to 4 Kg a.i./ha) were instrumental in the increasing length of shoot and

root (Figs. 163, 165), the weight of shoot and root (Figs. 164, 166), number of leaves (Fig. 167), fruits (Fig 168) and weight of fruits (Fig. 169). Simultaneously, noticeable reduction in the number of root-knot galls (Fig. 170) and J_2 larvae in soil (Fig. 171) were encountered at 1 to 4 Kg a.i./ha Aldicarb. Therefore, the study gave indication of flexibility in the range on efficacy of Aldicarb, where influence in terms of toxicity of this nematicide could be ruled out, up to the dose as high as 4 Kg a.i./ha. It is, therefore, obvious that an interesting set of variations have emerged from the investigations relating to pre-inoculation treatment of Fensulphothion, Carbofuran, Mocap, Phorate and Acephate, that have shown striking contrast from the efficacy of nematicides observed when post-inoculated treatments were applied. It has been illustrated in preceding text that summarily lower doses of nematicides were potentially more efficacious, particularly as far as the growth and yield aspects from Okra plants were concerned in pre-inoculation treatment proceedings. On the contrary, lower dosage of nematicides scarcely fovoured growth and yield parameters during post-inoculation treatment, and relatively higher dosage (> 2

Kg a.i./ha) controlled more frequently the formation of root galls. The author is, therefore, of the opinion that to avoid toxic influence of higher dosage during post-inoculation treatment, the pre-inoculation treatment of soil should be recommended to achieve better yield from Okra plants. Singh and Gaur (1988) illustrated that soil solarization of the nursery-bed area using a thin transparent polythene sheet for 2-4 weeks in summer and application of Carbofuran or Phorate @ 0.1 g a.i. m^{-2} before sowing could provide nematode-free healthy seedlings of transplanted crops like rice, vegetables, fruits, ornamentals etc. which perform better in field and reduce spread of nematodes. In their opinion the methods have been developed for reducing the cost and dose of nematicides. One such method included bare root-dip treatment of seedlings with emulsifiable Carbosulfan @ 500 ppm for 6 h protected transplanted vegetables like tomato, brinjal, chilli, pointed gourd etc. These workers confirmed that seed dressing of direct-seeded crops like mungbean, cowpea, blackgram, Okra, cucurbits etc. also reduced the attack of root-knot, reniform and lesion nematodes.

The studies of Reddy and Seshadri (1971) regarding ***M. incognita*** infestations on tomato, demonstrated that pre-inoculation treatment was better than post-inoculation treatment and in the latter treatment, the reduction in nematode population at all doses (4 to 8 Kg a.i./ha) of Aldicarb indicated systemic action. The conclusion of Amarnatha and Krishnappa (1992) in context of ***M. incognita*** infestation on sunflower confirmed that the performance of pesticides in improving plant growth was not varied with different time of application. But pre-inoculation treatment was comparatively superior over post-inoculation soil treatment. Ishwarbhatt and Krishnappa (1990) stressed that the treatment of soil around groundnut against ***M. javanica*** by 4 Kg a.i./ha dosage of pesticides at the time of inoculation was better in all respects. So the pre-inoculation treatment and the treatment at the time of inoculation resulting into higher yield suggested that nematicides will be more detrimental when these come in contact with larvae of nematodes directly. Rodriguez and Kaban (1982) illustrated that delaying nematicide applications until 8 weeks after planting of groundnut in

case of ***M. arenaria*** infections were found ineffective. Mcclina, Crozzoli and Rivas (1992) carried out experiments under green house conditions to assess the efficacy of Aldicarb (Temik 10 G), Carbofuran (Furadon 10 G) and Ethoprop (Mocap 10 G) at different doses to control ***M. incognita*** on ***Manihot esculenta***. Aldicarb 3 Kg a. i./ ha exhibited the most effective control. Next in efficacy, in that order, were Aldicarb 2 and 1 Kg ai/ha, Ethoprop at 3, 2 and 1 Kg a.i. /ha and Carbofuran 2 and 3 Kg ai/ha. Mustika and Zamuddin (1978), working on efficacy tests of some nematicides for the control of nematodes on black pepper reported that nemagon 75 EC Temik 10G, Furadon 3G, Nemacur 5G and Mocap 10G, were all effective in reducing nematode populations in ***P. nigrum***. Krishna Prasad (1977) tested Carbofuran, Aldicarb and Phorate at 1,2 and 3 Kg ai/ha to tomato seedling and reported that Carbofuran @ 3 Kg ai/ha resulted in the greatest reduction of nematodes.

Weingartner, Shumaker, Smart and Lambarti (1973) reported nematodes as vector of plant viruses. They applied Carbofuran, Aldicarb and Ethoprop to soil at 3.4 Kg a.i/ha in the row at planting. The nematode population

and disease prevalence were significantly reduced by Carbofuran alone or in various combinations. Weingartner, Shumaker, Dickson (1974) reported that the quality of Potato tuber was improved following treatment of soil with soil fumigants and non-volatile nematicides **viz.** Aldicarb, Carbofuran, Ethoprop. Aldicarb most consistently improved quality of products during 2 years it was tested.

Effect of Nematicides, Neemcake and Urea used as soil treatment against *M. incognita* on *A. esculentus*

The results showed that the combination of Neem cake and Urea with nematicides provided effective control over root-knot nematodes, ***M. incognita*** and increased growth and yield of Okra. The shoot length and shoot weight recorded maximum increase by the application of Fensulphothion, 2 Kg a.i. /ha + Neem cake 0.5 t/ha + Urea 15 Kg a.i./ha (T_4), followed by Carbofuran 2 Kg a.i./ha + Neem cake 0.5 t/ha + Urea 15 Kg a.i./ha (T_7) (Figs. 181, 182). The results obtained after these treatments were at par with those of uninoculated control (T_{11}). Likewise, root length (Fig. 183), Number of leaves (185), fruits (Fig. 186) and weight of fruits (Fig. 187) also recorded significant increase on application of Fensulphothion 2 Kg a.i./ha + Neem cake 0.5 t/ha + Urea 0.5 t/ha 15 Kg a.i./ha. It also provided maximum reduction in the number of root-knot galls (Fig. 188) and J_2 larvae in soil (Fig. 189). It was followed by 2 Kg a.i./ha dosage of Carbofuran (T_7) and 2 Kg a.i./ha dosage of

Mocap (T_{10}) in combination with Neem cake 0.5 t/ha and Urea 15 Kg a.i./ha to increase the various growth parameters of Okra. On the contrary, maximum root weight increase occurred on 1 Kg a.i./ha Fensulpothion + Neem cake 0.5 t/ha + Urea 15 Kg a.i./ha (T_3). The soil treated by Neem cake 0.5 t/ha (T_1) alone was not effective to increase growth and yield of Okra (Fig 181-189).

It suggested that combined application of Neem cake with nematicides along with Urea provided maximum growth of plant attributes. Simultaneously, severity of the root-knot disease was also reduced significantly by the aforesaid combined applications than single application of nematicides or Neem cake. The underlying mechanism possibly involved initial reduction of nematode populations in the soil at the first stage by nematicides' action. Later, as a follow up, the Neem cake and Urea supported better growth of Okra plant.

Apart from nematicidal properties of Neem cake, these are also considered to be organic nitrogenous manures which, when supplemented by Urea might increase aeration and solubilization of nutrients in soil.

This can regulate better growth and ultimately ensure more efficient uptake of nutrients. The combination of nematicides @ 1 or 2 Kg a.i./ha doses with Neem cake and Urea not only increased the growth and yield of plants but their cost-benefit ratio was higher than single application of higher dosage of nematicides. The combination of Neem cake and Urea provided maximum nutrition to the plant and potential of Neem cake to suppress nematodes was supplemented by nematicides **viz.** Carbofuran, Fensulphathion and Mocap. It resulted into better growth of plants and maximum reduction in the severity of root-knot disease.

The conclusions of Jain and Bhatti (1991) recommending highly efficacious potential of Aldicarb with Neem leaves to reduce nematode populations of ***M. javanica*** and increased yield of tomato are in close agreement with the findings of current investigation. The use of organic amendments including Neem and Castor cakes @ 1 t ha-1 has been found to reduce root-knot nematode damage to vegetables and groundnut by Singh and Gaur (1988). Their combinations with seed treatment with Carbosulfan 25ST @ 3% w/w or soil application of

Carbofuran @ 1 Kg m^{-1} in the experiments of these workers further improved efficacy.

The combined application of nutrients and nematicides has also been recommended for better yield by Rajendran and Naganathan (1980) and Krishna Rao, Padhi and Acharya (1987). Rao, **et al.** (1987) reported that Aldicarb 1 Kg a.i./ha + Neem cake 0.5 t/ha + Urea (15 Kg a.i./ha) followed by Carbofuran (1 Kg a.i./ha) + Neem care (0.5 t/ha) were the most effective applications in reducing the nematode populations of ***Rotylenchulus reniformis*** on Okra. These findings exhibited close agreement with the results of present experiments. The nematicidal component of Neem cake protects the emerging coleoptyle, and thus protected the seedling from the attack by nematodes in the study of Mojumdar and Mishra (1994). Drastic knock down effect of Fensulphothion, Carbofuran and Mocap on ***M. incognita*** in combination with Neem cake was more evident when combined with Neem cake than was applied alone. It was possible that the weakened juveniles in the Neem environment were highly prone to the poisoning action of Carbofuran, Fensulphothion and Mocap. Similar

conclusions were drawn by Gaur and Mishra (1989) on Lentil; and Ram and Gupta (1982) on chickpea. The combined treatment of Neem cake with Carbofuran or Fensulphothion or Mocap was found to be highly effective in increasing the yield.

Similar findings were concluded by Chakrabarti and Mishra (2001) on chickpea against root-knot nematodes who recommended that soil application with Neem seed powder in combination with Carbofuran (1 Kg a.i./ha) provided greater yield and increased cost benefit ratio. Nicola (1998) suggested that the cultivation of tomato cultivar's resistance to root-knot nematode in solarize soil under green house management practices is an alternative to methyl bromide and is very effective to control most of the soil borne pathogens. Weingartner, Mcsorby and Goth (1993) reported that ***M. incognita*** is the most important pathogen in southeastern Florida. Its management options included use of summer cover crops, delaying harvest of potato, soil fumigation and soil application of non-volatile nematicides and cultivar resistance. Though in a slightly different context, yet the double cropping pattern of potato-cotton was found to

decrease population densities of ***M. incognita*** in absence of nematicides (Crow, Weingartner and Dickson, 2000). Hoda **et al.** (2001) found that the highest percentage of nematode reduction was achieved by seed soaking in the extract of green manure (76%) followed by resistant inducer (64%) and the biocide (52%).

Seed plus soil treatment

The result of the experiments showed that the seed treatment together with the soil treatment provided substantial protection to the growing plants by reducing nematode infestations and the severity of root-knot disease that, in turn, resulted into better growth and yield of the plant. In these experiments, four nematicides Fensulphothion, Carbofuran, Mocap and Phorate were used as seed treatment at 1% w/w and 2% w/w concentration and the same nematicides were used as soil treatment at 1 Kg a.i./ha dosage along with Neem cake 0.5 t/ha and Urea 15 Kg a.i./ha.

The effect of seed treatment together with soil treatments on all the parameters (both in respect of increasing plant growth and yield and reducing nematodes

infestation) exhibited greater bio-statistical significance than untreated control ($CD_{5\%}$, 2.19 for shoot length 1.38 for shoot weight, 1.57 for root length, 3.01 for root weight, 1.20 for number of leaves, 1.44 for number fruits and 2.27 for fruit weight). It was also superior over single treatment of seed or soil treatment. Among these, the combination of seed treatment with Carbofuran 2% w/w + Fensulphothion 1 Kg a.i./ha along with Neem cake 0.5 t/ha and Urea 15 Kg a.i./ha (T_4) as soil treatment showed high degree of effectiveness in the growth of the length of shoot (Fig. 190) and root (Fig. 192) as well as weight of shoot (Fig. 191) and root (Fig. 193). The number of leaves (Fig. 194), fruits (Fig. 195) and weight of fruits (Fig. 196) were also improved by this treatment, and the root-knot galls (Fig. 197) and J_2 larvae in soil (Fig. 198) attained minimum level. The efficacy of next high order, after the aforesaid combination of nematicides with nutrients, was of the seed treatment with 2% w/w Fensulphotion + soil treatment with Mocap 1 Kg a.i./ha along with Neem cake 0.5 t/ha and Urea 15 Kg a.i./ha (T_6). The positive impact on length and weight of shoot and root (Figs. 190-193) of experimental plants were

recorded. The number of fruits and weight of fruits (Figs. 195, 196) exhibited maximum increase by Phorate 2 % w/w seed treatment + Carbofuran 1Kg a.i./ha along with Neem cake 0.5 t/ha and Urea 15 Kg a.i./ha (T_2). The application of these treatments increased the growth of plant to the extent as was obtained in uninoculated control (T_9) and double the extent in the inoculated but untreated control (T_{10}).

The seed treatment together with the soil treatment by nematicides as a measure of controlling plant-parasitic nematodes has been recommended by Paruthi and Gupta (1985) and Gupta and Verma (1990). The latter investigators reported maximum yield of mungbean when seed treatment with Carbofuran 1% w/w together with soil treatment with Phorate 1 Kg a. i./ha were combined. Paruthi and Gupta (1985) found that seed treatment followed by soil application was better than the seed treatment alone.

Conclusion and Recommendations

1. The positive association of the size of inoculum with exploding nemic populations of root - knot nematodes necessitated investigations on innovative methods for management of infestations in Okra crop.
2. The experimental findings on successful penetration by development stages of ***M. incognita*** within 12 hours into the root tissues of Okra cultivar, Pusa Sawani at 23^0C day and 18^0c night temperature paved the way for the completion of its life cycle after 33^{rd} day of inoculation.
3. The method of pre - inoculation soil treatment was unquestionably efficacious than that of post - inoculation treatment with organophosphate and carbamates group of non - fumigant nematicides.

4. The applications encompassing combined treatment of nematicide with Neemcake and Urea were the best to recommend for nemic control.
5. Besides efficacious potential of such a combination it allowed a restraint on excessive use of nematicides / pesticides commercially in field application
6. The treatment with Fensuphothion 2 Kg a. i. / ha + Neemcake 0.5 t/ha + Urea 15 Kg/ha is recommended.
7. The most effective method to attain better growth of Okra plants as well as yield turned out to be soil treatment combined with seed treatment to avoid phytotoxic influence of limited application of nematicides for successful management against ***M. incognita.***

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